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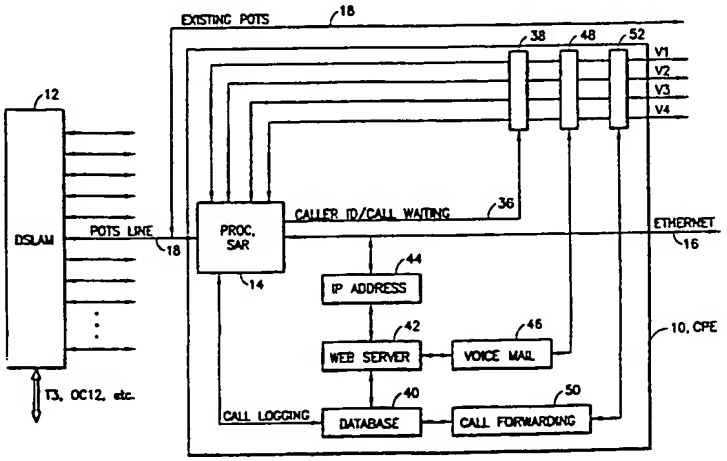
(54) Title: SYSTEM PROVIDING ENHANCED DIGITAL SUBSCRIBER LINE SERVICE



(57) Abstract: An enhanced DSL service is provided via CPE (10) and DSLAM (12) equipment which are adapted to provide additional telephony services. The additional services include multiplexing multiple digital voice lines (POTS lines 18) with the broadband data link (ethernet link 16) in a single G.lite connection (SAR 14), recovering AIN services (36 and 38) such as caller ID and call waiting, providing a connection (ethernet 16) to the customer's LAN and providing a firewall between the LAN and the internet (IP address 44), providing multiple LAN protocols, providing a secure web server (42) at the CPE (10), linking the web server (42) to a local database (40), voicemail system (46), and call forwarding logic (50). The invention enables instantaneous deployment of multiple phone lines, broadband access to the internet, a web presence with a firewall, advanced telephony features of voice mail, call accounting, call redirection, fax redirection, and access to all of the telephony features via the customer's LAN or the worldwide web.

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SYSTEM PROVIDING ENHANCED DIGITAL SUBSCRIBER LINE SERVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention broadly relates to a digital subscriber line (DSL) telecommunication service. More particularly, the invention relates to enhancements to a standardized DSL service known as G.lite.

2. State of the Art

In recent years there has been tremendous growth in the number of small offices and home offices, the so-called "SOHO" market. Concurrently, there has been tremendous growth in the need for advanced telecommunication services. Many years ago a small office could manage with one or two telephone lines. Today, the average American home has more than two phone lines. Most small/home offices and even many homes without offices require or desire a dedicated phone line for a fax machine in addition to one or two lines for regular telephone calls.

The demand for telecommunication service has been further heightened by the recently rapid growth of the internet. Interest in the internet is broad based with education, entertainment, and business all taking part in an information-communication-marketing revolution. The number of schools, homes, and businesses connecting to the internet is increasing at an accelerating rate. In addition, the type of information available via the internet is becoming more sophisticated.

Originally little more than hyperlinked text pages, the worldwide web has become a platform for multimedia information. It is now possible to receive live audio and video through a web site. It is even possible to "simultaneously" transmit and receive live audio and video via the internet thereby effecting "video conferencing". This type of multimedia communication is possible but requires a broadband link to the internet. While many universities and large businesses do have broadband internet connections, most homes, small offices, and home offices do not have broadband internet connections.

The economics of broadband connections were traditionally related to the number of users sharing the same connection. For example, a T1 connection provides the bandwidth of approximately thirty normal telephone lines, having an aggregate bandwidth of approximately 1.5 megabits/second. If an organization expects to have thirty or more members connected at the same time, then a T1 connection is reasonably cost effective. Moreover, a T1 connection is

fractional. Some of the bandwidth can be allocated to provide voice telephone lines while other bandwidth can be provided for data communications and internet access. However, the cost of a T1 connection cannot be justified in a home or small office. Until recently, the only alternatives available for the home or small office were a relatively high speed V.90 modem connected to POTS (plain old telephone service) or an ISDN connection to the local exchange company (LEC).

A V.90 modem provides the maximum bandwidth physically possible through the POTS circuit switched network, i.e. 56 kilobits/second. In actual practice, due to government regulation and other types of interference, a V.90 modem rarely reaches more than 50 kilobits/second in the downstream direction. At this rate, a live audio-video stream appears jerky in a window the size of a large postage stamp and the audio suffers from drop-outs. The upstream bandwidth for a V.90 modem is a mere 33kbs, thus making it unsuitable for transmitting streaming video or for video conferencing.

An ISDN connection provides a digital signal over two copper wire loops and is capable of providing a bandwidth of 128 kilobits/second. At this rate, a live audio-video stream can fill a television screen (400x512 pixels) but it still appears somewhat jerky and the audio is not as good as a television broadcast or a video tape. ISDN is acceptable for video conferencing but not for viewing video entertainment. In addition to providing more than double the bandwidth of a V.90 modem, ISDN has an advantage that it is somewhat fractional. Generally speaking, the user has two 64k channels which can be used separately or combined into one 128k channel. Thus, a single ISDN connection can provide two voice phone lines, one voice phone line plus one 64k data line, two separate 64k data lines, or one 128k data line. Nevertheless, one ISDN connection is significantly more expensive than two POTS lines which can be configured to provide near-ISDN performance.

Recently, several relatively inexpensive broadband technologies have been introduced, many claiming to provide T1-comparable or better bandwidth for less than the cost of an ISDN connection. These new technologies include cable modem, satellite modem, and various forms of digital subscriber line (DSL) technologies. Most of these services are asymmetric, providing a downstream bandwidth much greater than the upstream bandwidth. Indeed, the satellite modem requires POTS for the upstream connection and only the downstream link is provided via the satellite. Generally, an asymmetric link is acceptable for most internet access because most of the data is flowing in the downstream link and the upstream link is often used only to send a few characters and mouse clicks. However, a relatively generous upstream bandwidth (better than V.90) is required for services like video conferencing or web hosting. Therefore, the satellite modem is the least desirable of the new broadband services.

Cable modems offer the possibility of several megabits/second downstream bandwidth with several hundred kilobits/second upstream bandwidth. This downstream bandwidth should be sufficient to view live "video on demand" having the same quality as video tape. This upstream bandwidth (several hundred kbps) is sufficient for video conferencing and for limited web hosting. However, the cable modems do not provide fractional bandwidth (and neither do the satellite modems); and even more significantly, the bandwidth provided by cable modems and satellite modems is variable and limited by the number of simultaneous users. Cable modems are connected to a local cable television system which is essentially a data bus having a fixed bandwidth. As more users connect to the same bus, bandwidth allocations are diminished. Similarly, the bandwidth provided by a satellite is fixed and many users sharing the same satellite will diminish the amount of bandwidth available to each user.

Digital subscriber line technology encompasses several different DSL technologies collectively referred to as xDSL. The most interesting of these DSL technologies for homes and small offices is ADSL (Asymmetric Digital Subscriber Line). ADSL provides up to 6.1 megabits/second downstream bandwidth and up to 640 kilobits/second upstream bandwidth. ADSL is slightly fractional in that a small portion of the bandwidth can be allocated to a single voice telephone line. ADSL has an advantage over cable and satellite modems in that the bandwidth is relatively constant and is not affected by other ADSL customers in the same geographic area.

ADSL technology has been available for several years but has yet to be widely utilized in homes or small businesses. The primary reason for the slow deployment of ADSL technology is that it requires the installation of a "splitter" by a skilled technician at the customer premises.

Recently the ITU-T agreed on a provisional standard for a new form of ADSL known as G.lite, splitterless ADSL, or Universal ADSL. It is expected that the ITU-T will formally approve the standard (officially known as G.992.2) some time in the second half of 1999. The G.lite ADSL does not require a splitter at the customer premises. It operates on the same copper wire loop as the customer's existing POTS line by occupying a portion of the electromagnetic spectrum not used by POTS. Thus, it connects to a customer's existing POTS line without affecting the existing POTS service. At the LEC central office, a Digital Subscriber Line Access Multiplexer (DSLAM) separates the G.lite digital signal from the POTS analog signal.

The G.lite standard provides a downstream bandwidth of 1.5 megabits/second and an upstream bandwidth of up to 512 kilobits/second. While it does not provide as much bandwidth as ordinary ADSL, it provides substantial bandwidth for a relatively low cost. It is expected that G.lite modems will be sold to end users for approximately $200 and that G.lite

service will cost approximately $40 per month. Installation of the G.lite modem is the same as installing a V.90 modem, i.e. the user plugs one end into any phone jack and plugs the other end into a computer. No skilled technician is required. Like other xDSL services, G.lite is "always on" so long as there is electrical power to the customer premises. As mentioned above, although G.lite uses the same copper wire loop as existing POTS service, the existing POTS service is unaffected by the presence of G.lite. Therefore, the existing phone line can be used to make and receive calls while the G.lite modem maintains a connection to the internet. Unlike other certain xDSL services, a voice line (also called the "life line") is provided and is not affected by a power outage at the customer premises.

G.lite is expected to be the most popular form of all of the xDSL services. However, as G.lite is presently developing, its full potential will not be realized. Almost all of the vendors presently involved in G.lite are planning to sell G.lite modems as well as hybrid V.90/G.lite modems. Some computer manufacturers plan to include an internal G.lite/V.90 modem on a card in new computers sold after 1999. The industry has therefore focused on using G.lite to provide a single data link and marketing it as an upgrade from a V.90 modem.

SUMMARY OF THE INVENTION

It is therefore an object of the invention to provide methods and apparatus for enhancing the capabilities of G.lite ADSL service.

It is also an object of the invention to provide methods and apparatus for utilizing a single G.lite connection to provide multiple voice lines in addition to a broadband data link.

It is another object of the invention to provide methods and apparatus for utilizing a single G.lite connection to provide additional telephony services in addition to a broadband data link.

It is still another object of the invention to provide methods and apparatus which exploit the fact that the G.lite data link is always connected to the internet in order to provide advanced telephony services in addition to a broadband data link.

In accord with these objects which will be discussed in detail below, the apparatus of the invention includes customer premises equipment (CPE) and edge gateway equipment (either DSLAM equipment or a protocol converter for attachment to existing DSLAM equipment) which are adapted to implement the methods of the invention. The methods of the invention include multiplexing one or more digital voice lines with the broadband data link in a single

G.lite connection, while maintaining the existing POTS "life line" service which G.lite is designed to maintain. According to one embodiment designed for the SOHO market, four multiplexed voice lines are provided in addition to a broadband data link over a single enhanced G.lite connection. The voice lines are preferably compressed using the G.729 CELP standard which requires a bandwidth of 8 kilobits/second for each voice channel. The four voice lines thereby utilize only 32k of the broadband link bandwidth when all four voice lines are in use. According to another embodiment designed for the medium office or branch office (MOBO), eight multiplexed voice lines are provided. In this embodiment, up to 64k of the broadband link is "sacrificed" to provide eight voice lines. According to another MOBO embodiment, designed for offices which have a preinstalled PBX system, a virtual T1/E1 connection is provided by multiplexing thirty compressed digital voice lines. In this embodiment, up to 240k of the broadband connection is "sacrificed" to provide a T1/E1 voice trunk.

According to a preferred embodiment of the invention, traffic between the CPE unit and the central office DSLAM preferably utilizes ATM (asynchronous transfer mode) protocol or alternatively IP (internet protocol). The digital voice channels may be provided via ATM-AAL1, ATM-AAL2, or IP/AAL5. An advantage of using ATM is that it readily prioritizes voice traffic over the data traffic and dynamically re-assigns bandwidth to the data link as the voice lines go on hook. When using ATM-AAL1, each voice line is provided with a separate PVC between the CPE and the DSLAM. When using ATM-AAL2, one PVC is used for multiple voice lines and each voice line is assigned a channel ID. The single PVC is configured for variable bit rate-real time (VBR-RT) and is assigned bandwidth sufficient for all voice channels. When using IP/AAL5, the user will run a "wizard" to select which phones will use VOIP (voice over internet protocol). The wizard software enables the user to configure more or fewer voice lines, choose among different compression schemes, and allow the user to configure "no compression" 64k voice lines if desired.

According to another aspect of the invention, methods and apparatus are provided for recovering AIN services such as caller ID and call waiting which are normally lost in voice compression algorithms. According to the invention, the DSLAM is provided with means for reading the AIN service information before the voice channel is compressed and means for encoding this AIN information within an ATM cell (preferably in the management plane). The CPE is provided with means for reading the AIN information from ATM cells and for remodulating the AIN signals on the demultiplexed voice lines. According to a presently preferred embodiment, the DSLAM demodulates an AIN signal and builds an AAL fully protected packet (Type 3) containing the AIN information. The CPE extracts the AIN information, passes it to a database and also remodulates the AIN signal onto the appropriate voice line.

According to another aspect of the invention, the broadband data connection of the G.lite service is coupled to a customer's LAN. According to presently preferred SOHO and MOBO embodiments, the invention provides an Ethernet connection to the customer's Ethernet LAN. This may be accomplished by providing a four node Ethernet hub in the CPE or by providing a switched Ethernet connection in the CPE. According to a presently preferred SOHO embodiment, the invention also provides a "PCnet-Home" (part of the homePNA alliance) network connection which utilizes the existing POTS wiring for networking home computers. The "PCnet-Home" network signals are transmitted in a frequency band above the DSL signals. This enables an Ethernet-like (albeit slower) network without the need for additional cabling. According to a presently preferred embodiment, the CPE according to the invention also provides a "firewall" between the internet and the customer's LAN.

Another aspect of the CPE according to the invention is that it includes a secure web server. The web server is provided either in RAM or ROM within the CPE or is provided on an external device which is coupled to the CPE. Access to the web server is available via any internet connection (either locally or remotely), provided the appropriate username and password are entered. The web server is preferably provided with a data base which maintains data about the usage of the digital voice lines, e.g. a log of all incoming calls and outgoing calls and a name:phone number lookup database. Preferably, the log includes time/date stamps, calling number, called number, caller name, called name, etc.

According to another aspect of the invention, each of the digital voice lines is provided with digital voice mail which is also linked to the secure web server and the usage database. Access to the web server preferably provides an indication of the voicemail status and allows a user to retrieve the contents of voicemail via internet streaming audio technology.

According to still another aspect of the invention, the CPE is provided with means for dialing out on each of the voice lines in response to a network command and means for cross-connecting each of the voice lines with each other. Accordingly, the CPE is provided with software/firmware which enables call forwarding. Preferably, the call forwarding logic is configurable via the secure web server to redirect incoming calls on any of the digital voice lines to an outgoing call placed on another of the digital voice lines or on the existing POTS line. Preferably, the call redirection logic is configurable based on a number of criteria including the identity of the caller, the time of day, the date, etc. Incidentally, the dialing capability of the CPE, together with the caller ID database, can be used by computers coupled to the LAN to perform "auto dialing" and other local telephony services.

According to a preferred embodiment of the invention, each of the digital voice lines share a single phone number. According to one aspect of this embodiment, all incoming calls are connected to a voice mail announcement which provides options for the caller to connect to a selected one of the digital voice lines. According to another aspect of this embodiment, one or more of the digital voice lines are designated as a fax lines and automatic fax detection is provided to route fax calls to the fax lines. The automatic fax detection can be provided at the DSLAM or at the CPE.

The invention provides a "plug and play" telecommunication solution for a small office, home office, medium sized office, or branch office. It enables instantaneous deployment of multiple phone lines, broadband access to the internet, a web presence with a firewall, advanced telephony features of voice mail, call accounting, call redirection, fax redirection, and access to all of the telephony features via the customer's LAN or the worldwide web. Moreover, the sophistication of the solutions offered by the present invention make it an attractive communication solution for small branch offices of larger organizations where the broadband data connection can be used to provide intranet access rather than internet access.

According to another aspect of the invention, one or more DSLAM units may be provided in a multiple dwelling unit (e.g. apartment building, college dormitory, office building, hotel, etc.) so that the building owner/manager may provide each of the occupants or tenants with advanced telephony services and broadband internet access.

According to still another aspect of the invention, the customer's bandwidth is scalable by combining multiple G.lite connections to a single location through Inverse Multiplexing (IMA from the ATM forum) or alternatively MLPPP (multi-link PPP).

According to an alternate embodiment of the invention, a simulated standard G.lite connection jack (RJ-11) is provided on the CPE for connection to a pre-existing G.lite modem at the customer premises.

Additional objects and advantages of the invention will become apparent to those skilled in the art upon reference to the detailed description taken in conjunction with the provided figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a diagram representing a schematic functional abstraction of a SOHO CPE according to the invention;

Figure 2 is a diagram representing a schematic functional abstraction of a presently preferred embodiment of a DSLAM the invention at the LEC premises;

Figure 3 is a high level schematic diagram of a presently preferred hardware implementation of a SOHO CPE;

Figure 4 is a very high level diagram of a first embodiment of a MOBO CPE according to the invention;

Figure 5 is a very high level diagram of a second embodiment of a MOBO CPE according to the invention;

Figure 6 is a high level schematic diagram of a presently preferred CPE which combines ("bonds") the bandwidth of two or more xDSL lines;

Figure 7 is a high level schematic diagram of a SOHO CPE for use with a pre-installed G.lite modem;

Figure 8 is a high level schematic diagram of a protocol converter for use with an existing G.lite DSLAM to provide the services offered by the CPE;

Figure 9 is a pseudocode listing of operations performed at the DSLAM and the CPE when receiving a voice call from the PSTN;

Figure 10 is a pseudocode listing of operations performed at the CPE and the DSLAM when placing a voice call from the CPE;

Figure 11 is a schematic block diagram of a SOHO CPE illustrating the call accounting database according to the invention;

Figure 12 is a flow chart illustrating the call accounting functions of the invention;

Figure 13 is a pseudocode listing of the call accounting functions of the invention;

Figure 14 is a flow chart illustrating outbound fax processing according to the invention;

Figure 15 is a pseudocode listing of the outbound fax processing according to the invention;

Figure 16 is a flow chart illustrating inbound fax processing according to the invention;

Figure 17 is a pseudocode listing of the inbound fax processing according to the invention;

Figure 18 is a facsimile of a worldwide web page for accessing the call accounting, voicemail, and other programmable features of the invention;

Figure 19 is a facsimile of a main screen of a setup wizard according to the invention; and

Figure 20 is a schematic representation of the various screens of the setup wizard.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A. Multiplexed Voice and Data Lines

Turning now to Figures 1 and 2, the apparatus of the invention includes customer premises equipment (CPE) 10 and digital subscriber line access multiplexer (DSLAM) equipment 12 which are adapted to implement the methods of the invention. As described in more detail below with reference to Figure 8, the CPE of the invention may be used with an existing DSLAM through the use of a protocol converter installed at the DSLAM. Figure 1 shows a high level functional abstraction of one embodiment of the CPE equipment 10 and Figure 2 shows a high level functional abstraction of one embodiment of the DSLAM equipment 12. The CPE equipment 10 generally includes means for multiplexing one or more digital voice lines with the broadband data link in a single G.lite connection, while maintaining the existing POTS "life line" service which G.lite is designed to maintain. As shown in Figure 1, these means include a processor and ATM segmentation and reconstruction (SAR) device 14 which multiplexes and demultiplexes four voice lines (V1-V4) and an Ethernet link 16 onto a single modified G.lite connection via existing POTS line 18. The voice lines and the framed data link (e.g., Ethernet) are provided over separate virtual channels (VCs) according to the ATM standard protocol. Consequently, the DSLAM 12 includes a processor and ATM segmentation and reconstruction (SAR) device 20 for multiplexing and demultiplexing the four voice lines and ethernet link. Although the term "digital voice lines" is used herein, those skilled in the art will appreciate that the voice lines V1-V4 at the user end of the CPE 10 appear as ordinary analog voice lines and are preferably provided at the CPE via four two-wire or two four-wire RJ-11 jacks. The voice lines V1-V4 become digital between the CPE 10 and the DSLAM 12. The Ethernet link may be provided via a single RJ-45 jack, or the CPE 10 may incorporate an Ethernet hub having several RJ-45 jacks.

The DSLAM 12 is preferably provided with capabilities to handle sixteen subscriber xDSL (POTS) lines per card, designated in Figure 2 as 18 and 18a-18o. Further, the DSLAM 12 is coupled via a T1/E1 or T3/E3 link 22 to the public switched telephone network (PSTN) 24 for the purpose of passing voice. In addition, the DSLAM 12 is preferably coupled via link 26 to a broadband network such as an ATM network 28. Optionally, the DSLAM 12 may be coupled via a broadband link 30 to an Internet Service Provider (ISP) 32.

According to a presently preferred embodiment, the voice lines V1-V4 are compressed using the G.729 CELP standard which requires a bandwidth of approximately 8 kilobits/second for each voice channel. With this type of compression, the four voice lines V1-V4 utilize only 32k of the broadband link when all four voice lines are in use. Thus, even when all four voice lines are in use, the downstream bandwidth is still approximately 1.5 megabits/second and the upstream bandwidth is still approximately 337 kilobits/second. It will be appreciated that the Ethernet link 16 enables the CPE 10 to be coupled to a single customer computer or to a customer LAN. Thus, according to this first embodiment of the invention, the CPE 10, when coupled via an ordinary existing POTS line 18 to a DSLAM 12 provides telecommunication services sufficient for a small office or a home office (SOHO), i.e. multiple voice telephone lines and broadband internet access for multiple computers coupled to a network in the SOHO.

The digital voice channels V1-V4 may be provided via ATM-AAL1, ATM-AAL2, or IP/AAL5. An advantage of using ATM is that it readily prioritizes voice traffic over the data traffic and dynamically re-assigns bandwidth to the data link as the voice lines go on hook. When using ATM-AAL1, each voice line is provided with a separate permanent virtual channel (PVC) between the CPE 10 and the DSLAM 12. When using ATM-AAL2, one PVC is used for multiple voice lines and each voice line is assigned a channel ID. The single PVC is configured for variable bit rate-real time (VBR-RT) and is assigned a maximum bandwidth sufficient for all voice channels. When using IP/AAL5, the user will run a "wizard" (explained in more detail below with reference to Figures 19 and 20) to select which phones will use VOIP (voice over internet protocol).

B. Recovery of AIN Services

Those skilled in the art will appreciate that the compression algorithm used to compress the four voice lines V1-V4 may result in the loss of AIN services such as call waiting and caller ID. According to another aspect of the invention, the DSLAM 12 is provided with an AIN detection device 34 which reads the AIN signals on voice circuits before the voice circuits are compressed by the processor and SAR 20. The AIN detector 34 then passes the AIN data to the processor and SAR 20 which builds an AAL type 2 fully protected packet (Type 3) containing the AIN information. The processor and SAR 14 at the CPE 10 extracts the AIN information

from ATM cells and remodulates the AIN signal onto the appropriate voice line V1-V4. This is shown abstractly in Figure 1 by the line 36 and the box 38 which imply an analog AIN signal imposed on the voice lines V1-V4. Additional details regarding this aspect of the invention are described below with reference to Figure 9.

C. Telecommunications Accounting

According to a presently preferred embodiment (Fig. 1), the processor and SAR 14 at the CPE 10 also passes the AIN information to a database 40. The database 40 preferably also includes time/date stamps indicating the start and end of calls, calling number, called number, caller name, called name, etc. This "call log" is maintained by the processor and SAR 20 for both incoming and outgoing calls. Further, the call log may include a log of internet connections made via the ethernet link 16 and the identity of the network user making the internet connections. The database 40 therefore provides the foundation for a complete telecommunications accounting system. Additional details regarding this aspect of the invention are described below with reference to Figures 9-13.

D. Remote Access to Accounting

According to another aspect of the invention, access to the database 40 is provided via a secure web server 42 which is provided with a unique IP address (shown as 44 in Figure 1) and is coupled to the Ethernet network 16. As such, the web server 42 and the database 40 are accessible via the customer's LAN or via the internet, provided that the user supplies an appropriate username and password.

As shown in Figure 1, the web server is a functional block within the CPE 10. It will be appreciated that the web server may be provided either in RAM or ROM within the CPE 10 or may be provided on an external device which is coupled to the CPE 10. Additional details regarding this aspect of the invention are described below with reference to Figure 14.

E. Voice Mail

According to a presently preferred embodiment, the CPE 10 also includes a voice mail system 46. As shown in Figure 1, the voice mail system 46 is coupled at 48 to the analog portions of voice lines V1-V4 and is coupled to the web server 42. As stated above, Figure 1 is a functional abstraction and those skilled in the art will appreciate that the voice mail system 46 could be coupled to a digital portion of the voice lines. Indeed, it is preferred that the voicemail be stored in digital form. Since the voice lines V1-V4 enter the CPE 10 as packetized digital signals, it may be more convenient to implement the voice mail system without any digital to analog conversion during operation in response to an incoming call.

Preferably, the web server 42 includes software which correlates the call log data in the database 40 with the voice mail messages 46 and provides a display of time, date, caller ID, length of voice mail message, etc. According to the presently preferred embodiment, voice mail messages are retrieved via the web server 42 either as a digital sound file (e.g. .wav, .snd, .aiff, .moov, etc.) or as streaming audio (e.g. REAL AUDIO™ or QUICKTIME™). Thus, according to the invention, voice mail may be retrieved from anywhere in the world via the internet. Additional details regarding this aspect of the invention are described below with reference to Figure 18.

F. Call Forwarding

According to still another aspect of the invention, the CPE 10 is provided with means for dialing out on each of the voice lines V1-V4 in response to a network command and means for cross-connecting each of the voice lines with each other. Accordingly, the CPE 10 is provided with software/firmware which enables call forwarding. This functionality is shown schematically in Figure 1 as 50 and 52. Preferably, the call forwarding logic is configurable via the secure web server 42 to redirect incoming calls on any of the voice lines V1-V4 to an outgoing call placed on another of the voice lines or on the existing POTS line ("life line") 18. Although the call forwarding functionality 50 is shown in Figure 1 to be connected at 52 to the analog portions of voice lines V1-V4, those skilled in the art will appreciate that the redirection of ATM cells containing an incoming telephone call can be achieved efficiently without converting the digital data to analog data.

Preferably, the call redirection logic is configurable, via the web server 42, based on a number of criteria including the identity of the caller, the time of day, the date, etc. Thus, calls can be redirected to different numbers depending on the identity of the incoming caller, the time of day, the date, etc. The dialing capability of the CPE 10, together with the caller ID database 40, can be used by computers coupled to the LAN 16 to perform "auto dialing" and other local telephony services. Additional details regarding this aspect of the invention are described below with reference to Figures 10, 13, and 18.

G. One Number with Auto-Direction of Calls

According to a preferred embodiment of the invention, all of the voice lines V1-V4 share a single phone number. The lines can be configured to roll over from a busy line to the next on-hook line. Alternatively, all incoming calls are connected to a voice mail announcement which provides options for the caller to connect to a selected one of the voice lines V1-V4. According to another aspect of this embodiment, one or more of the voice lines V1-V4 are designated as a fax lines and automatic fax detection is provided to route fax calls to the fax line(s). As shown in Figure 2, automatic fax detection 54 can be provided at the DSLAM 12. Alternatively,

automatic fax detection can be provided at the CPE 10 in a number of ways. For example, each of the voice lines may be provided with a 1100hz tone detection circuit. Whenever an 1100hz tone of predetermined length is detected in an incoming call, it will be considered a fax call. Further, incoming fax calls can be directed to storage in the CPE. Alternatively, the setup Wizard can be used to have fax calls directed to an external storage device (not shown) such as a PC coupled to the LAN. The faxes can be identified in the call log database 40 and retrieved via the web server 42. Additional details regarding this aspect of the invention are described below with reference to Figures 9 and 14-17.

H. First Hardware Embodiment

The foregoing detailed description was directed to the functional aspects of the invention. Those skilled in the art will appreciate that the physical embodiment of the invention is preferably realized with a combination of hardware, firmware, and software. It will also be appreciated that the functionality described above may be provided in a single "box" or may be provided via a "box" coupled to a personal computer. Further, while the invention has been described with reference to G.lite ADSL, those skilled in the art will appreciate that the functionality of various aspects of the invention can be applied to other kinds of xDSL connections. Therefore, Figure 3 is a high level schematic example of one possible implementation of the invention.

Referring now to Figure 3, the SOHO CPE 100 includes a number of components which are coupled to each other via a PCI Bus 102 and which draw power from a common power supply 104. For clarity, no connection is shown between the power supply 104 and the other components in Figure 3. Those skilled in the art will appreciate, however, that the power supply 104 preferably provides five different voltages: -70 volts to ring the analog telephones on the voice lines, +5 volts for the telephone logic (SLAC) and the DSL logic (modem), +3.3 volts for the host processor and the memory, and ±15 volts for the DSL line drivers.

The CPE 100 is coupled to POTS via an RJ-11 jack which is coupled to an xDSL modem (preferably a G.lite modem) 106. The modem 106 provides a UTOPIA level 1 connection to an ATM SAR (segmentation and reconstruction module) 108 which is coupled to the PCI bus 102. An exemplary SAR is the IDT 77222 available from Integrated Device Technology Inc., 2975 Stender Way, Santa Clara, CA 95054.

A host processor 110 is coupled to the PCI bus 102 via a PCI bridge 112. Most of the functionality of the CPE 100 is handled by the host processor which manages and controls the IP functional layers L2TP (layer 2 tunneling protocol per IETF document RFC 1661) and MLPPP (multilink PPP) which is described below with reference to Figure 6. In addition, the

host processor provides signalling in the ATM management plane to set connections for the voice lines and the broadband data link. An exemplary host processor is the IDT 32364 RISC processor. An exemplary PCI bridge is the IDT 32134 PCI bridge and peripheral controller.

A voice processing DSP 114 is also coupled to the host processor 110 via the PCI bridge 112. The DSP 114 provides the compression functionality and is also used to packetize digitized voice and provide ATM adaptation for transport. An exemplary DSP is the Texas Instruments TMS 320LC549-66.

The DSP 114 is coupled via a PCM highway to an analog processor (SLAC) 116 which is shown in Figure 3 as sharing the same block as a short loop ringer driver (SLIC) 118. The SLIC and SLAC are coupled to the local analog loops 120 which provide the additional voice lines described above. The interface to the local analog loops is via RJ-11 jacks. SLIC and SLAC are also coupled to each other and the SLAC 116 interfaces with the analog lines 120, the DSP 114, and with the SLIC 118. The SLIC 118 interfaces with the SLAC 116 and with the analog lines 120. An exemplary SLAC is the Advanced Micro Devices AMD 29Q021/31. An exemplary SLIC is the Advanced Micro Devices AMD 79R79.

The broadband data link is provided by an Ethernet interface 122 which is coupled to the PCI bus 102 and by a PCnet-Home interface which may be coupled directly to the PCI bus 102 or through a firewall as described in more detail below. The Ethernet interface 122 may be a 10 base-T hub such as the AMD 79C978 which provides four RJ-45 connectors for category 5 wiring. The PCnet-Home interface may be supplied by the same AMD 79C978 and coupled to the same RJ-11 jack utilized by the modem 106. The PCnet-Home interface provides a slow Ethernet network (1 mbps) in a frequency band above the modem and allows the use of an existing POTS line to couple multiple personal computer to the CPE 100.

DRAM 126 is coupled to the PCI bridge and is available for buffering traffic into and out of the CPE 100. In particular, the DRAM 126 buffers packet data received from the SAR 108, the DSP 114, the Ethernet interface 122, and the PCnet-Home interface 124. The host processor examines the packets in the DRAM 126 and builds a transmit packet descriptor for the packets.

As shown in Figure 3, a secure web server is 128 is coupled to the Ethernet interface 122. As such, the web server could be implemented on a dedicated personal computer coupled via Ethernet to the CPE 100. According to a presently preferred embodiment, a firewall 130 is provided between the Ethernet interface 122 and a second protected Ethernet interface 132. The firewall prevents unsolicited traffic from entering onto the protected Ethernet 132 from the

unprotected Ethernet 122. In this embodiment, the PCnet-Home interface 124 is also part of the protected Ethernet 132.

Voice mail is preferably saved as compressed files, with the compression function provided either by the DSP or the host processor. The playback of voicemail is controlled by the host processor with decompression preferably controlled by the DSP.

I. First MOBO Alternative Embodiment

Figure 4 is a high level illustration of an alternative embodiment of the invention designed for a medium sized office or a branch office (MOBO). The CPE 200 according to this embodiment provides eight multiplexed voice lines 220, an Ethernet link 222, and, optionally, a secure web server 228.

J. Second MOBO Alternative Embodiment

Figure 5 is a high level illustration of a second alternative MOBO embodiment which is designed for an office with a preinstalled PBX system. The CPE 300 according to this embodiment multiplexes up to thirty compressed digital voice lines to provide a "virtual T1/E1 connection" 320 which is coupled to the customer's PBX 321. An Ethernet interface 322 is also provided to support data communications for one or more computers 328. In addition, a high speed serial port 329 is provided for programming, diagnostics, frame relay, or HDLC.

K. Scalable Bandwidth

Figure 6 is a high level diagram illustrating one embodiment of how two or more xDSL lines can be combined in a single CPE unit 400 to provide additional bandwidth. In this embodiment, two xDSL modems 406, 406' are provided for coupling to two xDSL lines (not shown). Each modem is coupled to a respective SAR/MUX 408, 408' and the SAR/MUX devices are both coupled to a multilink ppp (MLPPP) packetizer 460. The MLPPP 460 segments and distributes PPP packets between the two SAR/MUX devices and combines packets received from them. As such, the MLPPP 460 is coupled to a PPP device 462 which handles PPP packets between the MLPPP and an IP device 464. The Ethernet interface 422 is coupled to the IP device 464 such that all of the broadband traffic is multiplexed over the two modems 406, 406' using the MLPPP protocol. Voice traffic which is to be carried via ATM AAL1 is directed by the unit 466 to the second modem 406' so that all the voice traffic is carried on one of the DSL lines. Those skilled in the art will appreciate that an MLPPP server must be provided either at the DSLAM or at some node between the CPE and the ISP.

Another way to combine two or more xDSL lines in a single CPE utilizes ATM inverse multiplexing (IMA).

L. SOHO Embodiment for Use with an Existing DSL Modem

As mentioned above, it is expected that some computer manufacturers will soon be delivering computers with built-in G.lite/V.90 modems. It is expected that some SOHO applications will therefore have one or two computers with built-in G.lite/V.90 modems and perhaps no built-in Ethernet support. With this possibility in mind, another embodiment of the CPE according to the invention is provided. Figure 7 illustrates an embodiment of a CPE 510 which is similar to the CPE 10 shown in Figure 1 with similar reference numerals (increased by 500) referring to similar components. According to this embodiment, a G.lite emulator circuit 511 is provided and made accessible to the user via another RJ-11 connector 18'. This circuit provides a generic G.lite signal to a generic G.lite modem while the CPE 510 provides the enhanced G.lite services described above with reference to Figures 1 and 3. Though not shown in Figure 7, the CPE 500 may also provide Ethernet and/or PCnet-Home networking features. One function of the G.lite emulator 511 is psychological, i.e. it makes the user feel that the G.lite modem built into the new PC is not being wasted. In addition, however, it allows implementation of the enhanced DSL services of the invention without the need for Ethernet and PCnet-Home networking.

M. Implementation of the Invention with a Generic DSLAM

As described above, the invention expands and enhances the service provided by generic xDSL such as G.lite. Some of the features of the invention require the cooperation of the CPE with other equipment at the LEC office. One way to effect these features is to provide a custom(ized) DSLAM as suggested in the description of Figure 2. However, it is not necessary for a LEC to replace an existing DSLAM in order to provide the enhanced DSL services described herein. Figure 8 shows an example of a "protocol converter" 610 which provides the functionality previously shown in the DSLAM 12 described in Figure 2. It will be appreciated that in many ways, the protocol converter 610 also resembles the CPE equipment 510 described in Figure 7.

As shown in Figure 8, the protocol converter 610 includes a G.lite emulator 611 which couples to a generic G.lite DSLAM 12'. The G.lite emulator 611 is also coupled to a processor and SAR unit 620 which is used to multiplex the generic G.lite signal with several voice circuits, e.g. V1-V4, and transport the multiplexed signals via ATM over the POTS line 18 to the CPE according to the invention. The four voice circuits V1-V4 exit the protocol converter as ordinary POTS lines and are connected, together with the existing POTS line 18 to a PSTN switch 24. The protocol converter 61 is also provided with a circuit 634 for detecting AIN services from the voice lines and packetizing the AIN data as described above. Further, the protocol converter 61 is also provided with a circuit 654 for detecting call types such as a FAX call and causing it to be redirected at the CPE to a particular voice line chosen by the customer.

N. Hardware/Software/Firmware

As described herein above, one of the basic features of the invention is the integration of multichannel voice telephony with a broadband data link. This basic feature of the invention is preferably embodied in firmware (or software) resident at the DSLAM and the CPE. Figures 9 and 10 illustrate, in a high level manner, how the DSLAM and the CPE interact during incoming and outgoing voice calls.

Referring now to Figure 9, the pseudocode at lines 1-18 illustrates the operations performed at the DSLAM when a voice call is received from the PSTN for transport to the CPE over one of the multiplexed voice channels. At line 2 it is determined whether out-of-band signalling (e.g. TR-303) is enabled from the PSTN. If so, it is determined at line 3 if the out-of-band signalling is a call setup message. Alternatively, it is determined at line 6 if the out-of-band signalling is a drop call message. If the out-of-band signalling is a call setup message, an ATM management message is sent at lines 4-5 to the CPE to indicate a call setup request. If the out-of-band signalling is a drop call message, an ATM management message is sent at lines 6-7 to the CPE to indicate a drop call request. If it were determined at line 1 that out-of-band signalling is not enabled, the DSLAM monitors the inband channel for channel associated signalling (CAS) starting at line 9. If a ring signal is detected at line 10, the caller ID demodulator is enabled at line 11. The caller ID data is detected and is sent with a management message at line 12 for a call setup. At line 13 caller ID demodulation is left on so that AIN caller ID with call waiting can be recovered. If an idle code is detected at line 14, the DSLAM will wait a programmed number of seconds (x seconds) at line 15 before detecting a timeout at line 16 whereupon a management message will be sent at lines 17 and 18 to drop the call.

The pseudocode at lines 19-39 in Figure 9 illustrates the operations performed at the CPE when a call is received from the PSTN. If a call setup message is received from the management channel at line 20, the channel id configuration is retrieved from the CPE database at line 21 in Figure 9. The channel ID configuration determines, e.g., which of the four voice lines will receive the call, whether the call is to be forwarded, etc. The start of the incoming call is logged at line 22 and voice processing is enabled at line 23. The voice processing functions are defined in Figure 10 at lines 16-21. If it is determined at line 24 that the call is to be forwarded to a forward number, an outbound call to the forward number is commenced at line 25 and voice processing for the outbound call is commenced at line 26. The voice processing for the outbound call may be different from the voice processing for the inbound call which is being forwarded. E.g., one call may be sent VOIP and use different compression from the other call. The outbound voice processing provides the conversion at line 27. If it is determined at line 24/28 that the call is not to be forwarded, a ring signal is sent to the appropriate phone at line 29 and call processing is commenced at line 30. If it is determined at

lines 20/31 that the message on the management channel is not a call setup message, it is determined at line 32 whether the message is a caller ID message. If the message is a caller ID message, AIN modulation of the analog line is commenced at line 33 in Figure 9. If it is determined at lines 20/31/34 that the message on the management channel is not a call setup message and is not a caller ID message, it is determined at line 35 if the message is a drop call message. If so, the end of the call is logged at line 36. If it is determined at line 37 that the call was a forwarding call, the outbound call is dropped at line 38 and voice processing is disabled at line 39.

Turning now to Figure 10, the pseudocode at lines 1-24 illustrates operations performed at the CPE with respect to calls outbound from the CPE. If it is determined at line 2 that a phone coupled to one of the multiplexed voice lines of the CPE is taken off-hook, call processing begins at line 3 and the start of the call is logged at line 4. If it is determined at line 5 that out-of-band signalling is not enabled, i.e. the dial tone will be supplied by the PSTN, voice processing is enabled at line 6 so that the DTMF tones are sent directly over the voice line to the PSTN switch. The voice processing functions are shown in Figure 10 as a subroutine at lines 16-21 and include the functions of compression (based on channel id), voice detection (no encoding of silence), tone detector (for DTMF tones), echo cancellation, and packet formatting (based on channel configuration). If it is determined at lines 5/7 that out-of-band signalling is enabled, a dial tone is generated by the CPE and the DTMF tones are interpreted by the CPE. If it is determined at line 8 that a sufficient number of digits have been dialed to initiate a call, a call setup message is sent at line 9 through the management channel. If it is determined at line 10 that the called party has picked up and the call is now complete, the call log is updated at line 11 to indicate that the call was completed. If it is determined at line 12 that the telephone connected to the CPE has been hung up, a tear down call message is sent through the management channel at line 13; voice processing is disabled at line 14; and the log file is updated and closed at line 15.

At the DSLAM, it is determined at line 26 whether out-of-band signalling is available. If it is, the management channel is monitored to determine whether a call setup or call drop message is being sent from the CPE. If it is determined at line 27 that a call setup message is being sent from the CPE, a call setup message is sent via TR303 at line 28. If it is determined at line 29 that a call drop message is being sent from the CPE, a call drop message is sent via TR303 at line 30. The DSLAM also monitors TR303 messages from the PSTN. If, at line 31, the DSLAM receives a call proceeding message from the PSTN, a call proceeding message is sent to the CPE via the management channel at line 32. If, at line 33, the DSLAM receives a call established message from the PSTN, a call established message is sent to the CPE via the management channel at line 34. If it is determined at lines 26/35 that CAS signalling will be

used, and if an idle code is detected at line 36, the DSLAM will wait x seconds at line 37 and send a management message to drop the call at lines 39-40.

Figures 11-13 illustrate some of the hardware/software/firmware used to provide the call accounting features of the invention. As shown schematically in Figure 11, the CPE 700 is similar to the CPE 100 described in Figure 3. It has an xDSL modem 706, ATM processing 708, a host processor 710, voice processing 714, call processing 716, an Ethernet port 722, memory for buffers 726, and a web server 728. The host processor 710 is also provided with a database 740 for storing call accounting information in a data table 741. The data table contains information about every inbound and outbound call. According to a presently preferred embodiment, the information about outbound calls is slightly different from the information about inbound calls. Table 1 illustrates the type of information logged for inbound and outbound calls.

Outbound	Called #	Name	Channel ID	Start Time	End Time	Completed, Uncompleted
Inbound	Caller ID	Name	Channel ID	Start Time	End Time	Answered, Unanswered, Voicemail, Forwarded

TABLE 1

For outbound calls, the called number is recorded and the name of the person or organization associated with the called number is also stored, if the name is known from the local database of names and numbers. The channel ID of the phone making the call is stored. For example, in the CPE which provides four multiplexed voice lines, the channel ID would be a number from 1-4. The start time and end time of the call are recorded and, in the case of outbound calls, the completed or uncompleted status of the call is recorded to indicate whether the called party answered.

For inbound calls, the calling number (caller ID) is recorded and the name of the person or organization associated with the calling number is also stored, if the name is known from the local database of names and numbers. The channel ID of the phone receiving the call is stored. The start time and end time of the call are recorded and, in the case of inbound calls, the answered-unanswered-voicemail-forwarded status of the call is also recorded.

Figure 12 illustrates a simplified flow chart of how call accounting is accomplished and Figure 13 illustrates pseudocode for call accounting. Referring now to Figure 12 and with reference to Figure 13, the call accounting function waits in an idle state at 800 until it is

determined at 802 that call is being originated or is incoming. If it is determined at 802 that a call is being originated, originate call processing is initiated at 804. The pseudocode for the originate call processing is shown in Figure 13 at lines 1-14. The first step shown in Figure 12 is the create call entry at 806. This involves several steps listed at lines 2-9 in Figure 13, i.e. getting a pointer to the entry (line 3), inserting the called number and name (lines 4-5), indicating that the call is an outbound call (line 6), inserting the channel ID (line 7), and inserting the start time (line 8). All of this information is logged to a single entry in the database as shown at 808 in Figure 12 which corresponds to the entry pointer which was taken at line 3 in Figure 13. As shown in Figure 13 at line 9, after the log entry is complete, the entry pointer is passed to the originate call processing so that other outbound calls may be logged while the current call is still pending. This is illustrated in Figure 12 by the dotted line between 806 and 810. When it is determined at 810 that the outbound call has terminated, the outbound call entry is retrieved and updated. As shown in Figure 13, when the outbound call terminates, the entry pointer for the data entry is retrieved at line 11, the call end time is inserted at line 12, and the status of the call (completed or uncompleted) is entered at line 14. As shown in Figure 12, the call accounting function then returns to the idle state at 800.

If it is determined at 802 that there is an inbound call, the call accounting function enters the answer processing mode at 814. This mode is illustrated in Figure 13 at lines 15-28. The first step shown in Figure 12 is the create call entry at 816. This involves several steps listed at lines 16-22 in Figure 13, i.e. getting a pointer to the entry (line 17), inserting the caller number and name (lines 18-19), indicating that the call is an inbound call (line 20), inserting the channel ID (line 21), and inserting the start time (line 22). All of this information is logged to a single entry in the database as shown at 818 in Figure 12 which corresponds to the entry pointer which was taken at line 17 in Figure 13. As shown in Figure 13 at line 23, after the log entry is complete, the entry pointer is passed to the answer call processing so that other inbound calls may be logged while the current call is still pending. This is illustrated in Figure 12 by the dotted line between 816 and 820. When it is determined at 820 that the inbound call has terminated, the inbound call entry is retrieved and updated. As shown in Figure 13, when the inbound call terminates, the entry pointer for the data entry is retrieved at line 25, the call end time is inserted at line 26, and the status of the call (answered, unanswered, voicemail, forwarded) is entered at line 28. As shown in Figure 12, the call accounting function then returns to the idle state at 800.

O. Enhanced FAX Handling

Another feature of the invention is that the CPE may be provided with software/firmware which enables enhanced handling of incoming and outgoing fax calls. More particularly, the CPE may log all incoming and outgoing fax calls for accounting purposes. Further, the CPE

may emulate a faxmodem, store incoming fax documents as files on a storage device, send files as outgoing faxes from any PC coupled to the network. It may also be configured to forward copies of faxes to other locations. Figures 14-17 illustrate examples of the software/firmware which enables enhanced handling of incoming and outgoing fax calls.

As shown in Figure 14, the software/firmware lies in an idle state at 900 until activated at 902 by an incoming or outgoing fax. If it is determined at 902 that an outgoing fax is being sent, the software/firmware follows the steps shown in the remainder of Figure 14 and as illustrated in the pseudocode listing of Figure 15. If it is determined at 902 that an incoming fax is being sent, the software/firmware follows the steps shown in Figure 16 and as illustrated in the pseudocode listing of Figure 17.

Turning now to Figures 14 and 15, if it is determined that an outgoing fax is being received by the CPE, fax originate processing begins at 904 in Figure 14 (line 1 of Figure 15). The first step in processing an outgoing fax is to determine at 906 (lines 2-4) whether the fax is originating from a real fax machine or from a data file. If the fax is originating from a data file, a fax emulation process is called at line 5 in Figure 15. The fax emulation process includes a setup at line 6 (908 in Figure 14) followed by getting the file at line 7 (910 in Figure 14). The "get file" operation can retrieve the file from storage in the CPE (912 in Figure 14, line 8 in Figure 15) or from a PC on the network (914 in Figure 14, line 10 in Figure 15). As will be appreciated from the following descriptions of incoming fax treatment and the descriptions of the setup wizards, the former option of faxing from storage in the CPE is most useful when forwarding a fax which was previously received. Following file retrieval, the emulation process emulates a fax modem (916 in Figure 14, line 11 in Figure 15). After the emulation process is completed, i.e. fax transmission begins, the fax originate process goes to handling the fax call as if it were originating from a fax machine coupled to one of the voice lines (918-924 in Figure 14, lines 12-25 in Figure 15). More particularly, the process creates a fax call entry (918 in Figure 14, line 13 in Figure 15). This includes writing certain information about the call in a database (920 in Figure 14, lines 14-20 in Figure 15). Preferably, the information includes the fax number called, the name of the called party (if available from pre-existing database(s)), the source of the fax (the channel ID or file name), and the start time. When the call is terminated (922 in Figure 14, line 21 in Figure 15), the ending time is inserted in the call log and the status of the call (completed/uncompleted) is added to the call log (924 in Figure 14, lines 23-25 in Figure 15).

Turning now to Figures 16 and 17, if it is determined that an incoming fax is being received by the CPE, fax answer processing begins at 1002 in Figure 16 (line 1 of Figure 17). The first step in processing an incoming fax is to create a call entry in the database (1004, 1006

in Figure 16, lines 2-10 in Figure 17). The entry preferably includes fax number calling (if available from Caller ID), the name of the calling party (if available from pre-existing database(s) or Caller ID), the destination of the fax (the channel ID or file name), and the start time (lines 4-9 in Figure 17). The CPE will have been set up to direct an incoming fax call either to a fax machine coupled to one of the voice lines or to a disk file. This choice is illustrated at 1008 in Figure 16 and line 11 in Figure 17. If the incoming fax is destined for a disk file, fax modem emulation begins at 1010 in Figure 16 and line 13 in Figure 17. Software/firmware emulates a faxmodem at 1012 and saves a file at 1014 to either storage in the CPE or storage on a PC coupled to the LAN (1016 in Figure 16, lines 16-19 in Figure 17). One of the features of the invention is that the CPE can be programmed to forward a copy of a fax to another location. This feature is available only when incoming faxes are saved to disk rather than directed to a stand alone fax machine. It will be appreciated that the number to which the fax is forwarded may be determined from a list of instructions. For example, the "forward to" number may be different depending on from where the fax was received, i.e. depending on the Caller ID written at line 5 of Figure 17. Alternatively, the "forward to" number may be different depending on the time of day or date. The fax forwarding determination is made at 1018 in Figure 16 (line 20 in Figure 17). If forwarding has been programmed, the fax file which was saved at 1014 is sent via a series of steps shown generally at 1020 in Figure 16 (lines 22-40 in Figure 17) which are essentially the same as described above with regard to outgoing fax transmissions from disk files. If it is determined at 1008 in Figure 16 (line 11 in Figure 17) that the incoming fax is destined for a fax machine coupled to one of the voice lines, the incoming fax is simply logged at 1022-1026 in Figure 16 (lines 41-47 in Figure 17). This logging procedure is also performed after fax file reception if no forwarding is enabled or after fax forwarding if it is enabled. When all of the incoming fax processing is complete at 1024, the program returns to the idle state 900 in Figure 14.

P. User Interface, Remote Access, Retrieval of Voicemail

As mentioned above, one of the features of the invention is the provision of a secure web server for configuration and remote access. Figure 18 illustrates a user interface through a "web browser". This interface may be accessed locally by a computer coupled to the CPE, or anywhere in the world by a computer coupled to the worldwide web, provided the appropriate security keys are present. Preferably, the web server is a secure web server using 128-bit strong encryption technology. The user interface appears in a browser window 1100 which is accessed by an IP address which is associated with the CPE. As shown in Figure 14, the address is a registered address, http://www.georgeathome.com. Alternatively, the address may be an assigned address, e.g. http://201.333.231.900.

According to a preferred embodiment, the web page interface provides access via hot linked buttons to several services such as user setup 1102, call summary 1104, forwarding setup 1106, directory setup 1108, etc. The screen shown in Figure 18 is the call summary screen. The call summary may be displayed in different formats. These can be pull down menus, e.g. 1110, 1112, 1114 which arrange the entries according to inbound or outbound, date and time, or name of caller/called. The display table 1116 shows the information from the call accounting database including whether an inbound call left a voicemail message. Indications of voicemail messages are preferably hot linked to a voicemail page where voicemail may be played or downloaded as described above.

Those skilled in the art will appreciate that the hotlinked buttons 1102, 1106, 1108 will link to other web pages where data may be exchanged interactively in order to configure the CPE, arrange to have calls forwarded, and to edit the directory. This is the directory where the user information is manipulated via the web browser. The actual data is stored in the CPE or on an external storage device. A web browser applet may be provided for additional setup parameters that are saved locally on the host. For example, the Caller Number can be saved in the CPE while the Caller Name, Address, etc., for that Caller Number can be saved by the web browser applet on an external device. Hence every time the web browser applet receives the Caller Number from the CPE database it retrieves the data for that Called Number. This minimizes the storage required on the CPE.

Q. Plug and Play Setup

As mentioned above, the invention provides a "plug and play" telecommunication solution for a small office, home office, medium sized office, or branch office. It enables instantaneous deployment of multiple phone lines, broadband access to the internet, a web presence with a firewall, advanced telephony features of voice mail, call accounting, call redirection, fax redirection, and access to all of the telephony features via the customer's LAN or the worldwide web. Moreover, the sophistication of the solutions offered by the present invention make it an attractive communication solution for small branch offices of larger organizations where the broadband data connection can be used to provide intranet access rather than internet access.

In order to further enhance the "plug and play" aspects of the invention, it is desirable to provide several firmware or software "wizards" so that the user may quickly configure the CPE equipment. Such wizards may be contained in ROM or SRAM within the CPE, or may be provided on a CDROM or diskette for use with the user's personal computer. As mentioned above, one of the primary features of the wizards will be to allow the user to configure the number and type of voice lines, e.g. the bandwidth, compression algorithm, and transport medium (ATM or VOIP). Wizards may also be provided to configure the web server, the voice mail system, the database for call accounting, call forwarding features, dedicated fax lines, etc.

Such sophisticated wizards will enable the user to rapidly configure a sophisticated telecommunications system in a matter of minutes.

Figures 19 and 20 illustrate examples of setup wizards for configuring the CPE of the invention. As shown in Figure 19, the main screen 1200 of the setup wizard offers options 1202 for manually configuring various aspects of the CPE such as voicemail, fax, etc. These selections can be used at any time to reconfigure the CPE. Selections 1204 operate a "walk through" setup where the wizard prompts the user to configure every feature of the CPE or accept a default configuration. Figure 20 illustrates the overall organization of the wizard. After a splash screen 1300, the main screen 1200 is displayed. Each feature configuration involves the display of one or more screens as shown at 1400 and 1500. When setup is completed, a closing screen 1600 is displayed.

According to a presently preferred embodiment, the setup wizard is provided on a disk (e.g. a CDROM). After the CPE is coupled to a PC via Ethernet or PCnet-Home, the wizard software is launched. The wizard locates the CPE using standard internet protocol (IP) signals such as PING or ICMP. The wizard also recognizes the model number (defined in the MAC address) of the CPE and thereby knows what features are programmable. As mentioned above, different embodiments (models) of the CPE will be provided with different features and thus the wizard will operate differently for different models.

R. Applications Beyond SOHO and MOBO

According to another aspect of the invention, one or more DSLAM units may be provided in a multiple dwelling unit (e.g. apartment building, college dormitory, office building, hotel, etc.) so that the building owner/manager may provide each of the occupants or tenants with advanced telephony services and broadband internet access.

There have been described and illustrated herein several embodiments of enhanced DSL services. While particular embodiments of the invention have been described, it is not intended that the invention be limited thereto, as it is intended that the invention be as broad in scope as the art will allow and that the specification be read likewise. Thus, while particular hardware, software, firmware, and block diagram arrangements have been shown and described, it will be appreciated that other hardware, software, and firmware could be utilized and configured differently to obtain the desired functions. Also, while a certain voice compression algorithm was described as preferred, it will be appreciated that other such algorithms could be utilized. Further, while particular numbers of voice lines and Ethernet connections were described as preferred with respect to different embodiments, it will be appreciated that different numbers of such lines and connections could be utilized as desired. It will therefore be appreciated by those skilled in the art that yet other modifications could be made to the provided invention without deviating from its spirit and scope as so claimed.

Claims:

1. An enhanced digital subscriber line system, comprising:

a) customer premises equipment, said customer premises equipment including first means for multiplexing/de-multiplexing a plurality of voice telephone lines over a single digital subscriber line; and

b) central office equipment coupled to said customer premises via the single digital subscriber line, said central office equipment including second means for multiplexing/de-multiplexing a plurality of voice telephone lines over the single digital subscriber line, wherein

said first means for multiplexing/de-multiplexing is user configurable whereby a user can select the number of said plurality of voice telephone lines.

2. A system according to claim 1, wherein:

said first means for multiplexing/de-multiplexing a plurality of voice telephone lines includes first means for multiplexing/de-multiplexing a plurality of voice telephone lines and at least one broadband data link, and

said second means for multiplexing/de-multiplexing a plurality of voice telephone lines includes second means for multiplexing/de-multiplexing a plurality of voice telephone lines and at least one broadband data link.

3. A system according to claim 2, wherein:

the single digital subscriber line is a G.lite digital subscriber line.

4. A system according to claim 2, wherein:

said customer premises equipment includes local area network coupling means for coupling said at least one broadband data link to a local area network.

5. A system according to claim 4, wherein:

said local area network coupling means includes one of an Ethernet port, an Ethernet hub, or a PCnet-Home port.

6. A system according to claim 4, wherein:

said first means for multiplexing/demultiplexing is user configurable via said local area network coupling means.

7. A system according to claim 1, wherein:

said customer premises equipment and said central office equipment each include compression/decompression means for compressing/decompressing at least one of said plurality of voice telephone lines.

8. A system according to claim 7, wherein:

said customer premises equipment includes means for recovering AIN data lost during compression of said at least one of said plurality of voice telephone lines.

9. A system according to claim 1, wherein:

said customer premises equipment further includes

call logging means for logging data regarding calls carried on said plurality of voice telephone lines; and

secure web server means coupled to said call logging means for providing secure access to said data regarding calls carried on said plurality of voice telephone lines.

10. A system according to claim 9, wherein:

said call logging means includes means for logging numbers dialed, logging caller ID information, logging call start time, and call end time.

11. A system according to claim 1, wherein:

said customer premises equipment further includes

configurable call forwarding means for redirecting an inbound call received on one of said plurality of voice telephone lines to an outbound call on another of said plurality of voice telephone lines.

12. A system according to claim 11, wherein:

said customer premises equipment further includes

secure web server means coupled to said call forwarding means for providing secure access to said call forwarding means such that said call forwarding means may be configured via the worldwide web.

13. A system according to claim 1, wherein:

said central office equipment further includes

means for coupling said central office equipment unit to the PSTN;

means for determining whether a call inbound from the PSTN is a fax call; and

means for routing fax calls to a predetermined one of said plurality of voice telephone lines.

14. A system according to claim 1, wherein:

said customer premises equipment further includes

voicemail means for receiving voicemail on at least one of said plurality of voice telephone lines; and

secure web server means coupled to said voicemail means for providing secure access to said voicemail means such that said voicemail means may be accessed via the worldwide web.

15. A system according to claim 2, wherein:

said customer premises equipment further includes

coupling means for coupling said customer premises equipment unit to a second digital subscriber line, whereby

said at least one broadband data link adapted to be coupled to at least one personal computer can be increased in bandwidth.

16. A customer premises equipment unit for use with an enhanced digital subscriber line system which includes central office equipment which is coupled to the customer premises by a digital subscriber line, said customer premises equipment unit comprising:

a) a digital subscriber line modem adapted to be coupled to the digital subscriber line;

b) a plurality of analog phone lines adapted to be coupled to analog telephone sets; and

c) multiplexer/demultiplexer means for multiplexing/de-multiplexing the plurality of analog telephone lines over the digital subscriber line, wherein

said multiplexer/demultiplexer means is user configurable whereby a user can select the number of said plurality of voice telephone lines which are multiplexed/demultiplexed over the digital subscriber line.

17. A customer premises equipment unit according to claim 16, further comprising:

d) at least one broadband data link adapted to be coupled to at least one personal computer, wherein

said multiplexer/demultiplexer means includes means for multiplexing/demultiplexing the plurality of analog telephone lines and the at least one broadband data link over the digital subscriber line.

18. A customer premises equipment unit according to claim 16, wherein:

said digital subscriber line modem is a G.lite modem.

19. A customer premises equipment unit according to claim 17, further comprising:

e) local area network coupling means for coupling said at least one broadband data link to a local area network.

20. A customer premises equipment unit according to claim 19, wherein:

said local area network coupling means includes one of an Ethernet port, an Ethernet hub, and a PCnet-Home port.

21. A customer premises equipment unit according to claim 17, wherein:

said multiplexer/demultiplexer means is user configurable via the at least one personal computer coupled to said at least one broadband data link.

22. A customer premises equipment unit according to claim 16, further comprising:

d) compression/decompression means for compressing/decompressing data transmitted on at least one of said plurality of voice telephone lines.

23. A customer premises equipment unit according to claim 22, further comprising:

e) AIN recovery means for recovering AIN data lost during compression of said data transmitted on at least one of said plurality of voice telephone lines.

24. A customer premises equipment unit according to claim 16, further comprising:

d) call logging means for logging data regarding calls carried on said plurality of analog phone lines; and

e) secure web server means coupled to said call logging means for providing secure access to said data regarding calls carried on said plurality of analog phone lines.

25. A customer premises equipment unit according to claim 24, wherein:

said call logging means includes means for logging numbers dialed, logging caller ID information, logging call start time, and call end time.

26. A customer premises equipment unit according to claim 16, further comprising:

d) configurable call forwarding means for redirecting an inbound call received on one of said plurality of analog phone lines to an outbound call on another of said plurality of analog phone lines.

27. A customer premises equipment unit according to claim 26, further comprising:

e) secure web server means coupled to said call forwarding means for providing secure access to said call forwarding means such that said call forwarding means may be configured via the worldwide web.

28. A customer premises equipment unit according to claim 16, further comprising:
d) voicemail means for receiving voicemail on at least one of said plurality of analog phone lines; and
e) secure web server means coupled to said voicemail means for providing secure access to said voicemail means such that said voicemail means may be accessed via the worldwide web.

29. A customer premises equipment unit according to claim 17, further comprising:
e) coupling means for coupling said customer premises equipment unit to a second digital subscriber line, whereby
said at least one broadband data link adapted to be coupled to at least one personal computer can be increased in bandwidth.

30. A central office equipment unit for use with an enhanced digital subscriber line system which includes a customer premises equipment adapted to be coupled to the central office equipment unit by a digital subscriber line, said central office equipment unit comprising:
a) multiplexer/demultiplexer means for multiplexing/de-multiplexing a plurality of voice telephone lines over the digital subscriber line; and
b) means for coupling said central office equipment unit to the PSTN, wherein
said multiplexer/demultiplexer means is responsive to the customer premises equipment such that the number of said plurality of voice telephones can be changed by the customer premises equipment.

31. A central office equipment unit according to claim 30, wherein:
said multiplexer/demultiplexer means includes means for multiplexing/demultiplexing a plurality of voice telephone lines and at least one broadband data link over the digital subscriber line.

32. A central office equipment unit according to claim 30, wherein:
said digital subscriber line modem is a G.lite modem.

33. A central office equipment unit according to claim 30, further comprising:
c) compression/decompression means for compressing/decompressing data transmitted on at least one of said plurality of voice telephone lines.

34. A central office equipment unit according to claim 33, further comprising:
d) AIN preserving means for preserving AIN data lost during compression of said data transmitted on at least one of said plurality of voice telephone lines.

35. A central office equipment unit according to claim 30, further comprising:

c) means for coupling said central office equipment unit to the PSTN;

d) means for determining whether a call inbound from the PSTN is a fax call; and

e) means for routing fax calls to a predetermined one of said plurality of voice telephone lines.

36. Apparatus for recovering AIN data in a compressed voice telephone link, said apparatus comprising:

a) AIN data detection means for detection of AIN information prior to compression of the voice telephone link;

b) AIN data encoding means for representing data detected with said AIN data detection means as digital data;

c) digital data transmission means for transmitting said digital data with the compressed voice telephone link;

d) digital data detection means for detecting said digital data prior to decompression of the voice telephone link; and

e) AIN data remodulation means for remodulating the AIN data with the decompressed voice telephone link.

37. Apparatus according to claim 36, wherein:

said digital data transmission means is asynchronous transfer mode means.

38. Apparatus according to claim 37, wherein:

said digital data is transmitted in the management plane of said asynchronous transfer mode means.

39. A customer premises equipment unit for use with an enhanced digital subscriber line system which includes central office equipment which is coupled to the customer premises by a digital subscriber line, said customer premises equipment unit comprising:

a) a digital subscriber line modem adapted to be coupled to the digital subscriber line;

b) at least one analog phone line adapted to be coupled to an analog telephone set;

c) multiplexer/demultiplexer means for multiplexing/de-multiplexing said at least two analog telephone lines over the digital subscriber line;

d) compressor/decompressor means for compressing the signals from said at least two analog telephone lines and for decompressing the signals to said at least two analog telephone lines; and

e) AIN data remodulation means for remodulating analog AIN data with the decompressed signals to said at least two analog telephone lines.

40. A customer premises equipment unit according to claim 39, further comprising:

f) at least one broadband data link adapted to be coupled to at least one personal computer, wherein

said multiplexer/demultiplexer means includes means for multiplexing/demultiplexing the plurality of analog telephone lines and the at least one broadband data link over the digital subscriber line.

41. A customer premises equipment unit according to claim 39, wherein:

said digital subscriber line modem is a G.lite modem.

42. A customer premises equipment unit according to claim 39, further comprising:

f) local area network coupling means for coupling said at least one broadband data link to a local area network.

43. A customer premises equipment unit according to claim 42, wherein:

said local area network coupling means includes one of an Ethernet port, an Ethernet hub, and a PCnet-Home port.

44. A customer premises equipment unit according to claim 38, further comprising:

f) call logging means for logging data regarding calls carried on said plurality of analog phone lines; and

g) secure web server means coupled to said call logging means for providing secure access to said data regarding calls carried on said plurality of analog phone lines.

45. A customer premises equipment unit according to claim 44, wherein:

said call logging means includes means for logging numbers dialed, logging caller ID information, logging call start time, and call end time.

46. A customer premises equipment unit according to claim 38, further comprising:

f) configurable call forwarding means for redirecting an inbound call received on one of said at least two analog phone lines to an outbound call on another of said at least two analog phone lines.

47. A customer premises equipment unit according to claim 46, further comprising:

g) secure web server means coupled to said call forwarding means for providing secure access to said call forwarding means such that said call forwarding means may be configured via the worldwide web.

48. A customer premises equipment unit according to claim 38, further comprising:

f) voicemail means for receiving voicemail on at least one of said at least two analog phone lines; and

g) secure web server means coupled to said voicemail means for providing secure access to said voicemail means such that said voicemail means may be accessed via the worldwide web.

49. A customer premises equipment unit according to claim 38, further comprising:

f) coupling means for coupling said customer premises equipment unit to a second digital subscriber line.

50. A customer premises equipment unit for use with an enhanced digital subscriber line system which includes central office equipment which is coupled to the customer premises by a digital subscriber line, said customer premises equipment unit comprising:

a) a digital subscriber line modem adapted to be coupled to the digital subscriber line;

b) a plurality of analog phone lines adapted to be coupled to analog telephone sets;

c) at least one broadband data link adapted to be coupled to at least one personal computer;

d) multiplexer/demultiplexer means for multiplexing/de-multiplexing the plurality of analog telephone lines and the at least one broadband data link over the digital subscriber line;

e) call logging means for logging data regarding calls carried on said plurality of analog phone lines; and

f) secure web server means coupled to said call logging means for providing secure access to said data regarding calls carried on said plurality of analog phone lines.

51. A customer premises equipment unit according to claim 50, wherein:

said call logging means includes means for logging numbers dialed, logging caller ID information, logging call start time, and call end time.

52. A customer premises equipment unit according to claim 50, wherein:

said digital subscriber line modem is a G.lite modem.

53. A customer premises equipment unit according to claim 50, further comprising:

g) local area network coupling means for coupling said at least one broadband data link to a local area network.

54. A customer premises equipment unit according to claim 53, wherein:

said local area network coupling means includes at least one of an Ethernet port, an Ethernet hub, and a PCnet-Home port.

55. A customer premises equipment unit according to claim 50, wherein:

said multiplexer/demultiplexer means is user configurable via the at least one personal computer coupled to said at least one broadband data link.

56. A customer premises equipment unit according to claim 50, further comprising:

g) compression/decompression means for compressing/decompressing data transmitted on at least one of said plurality of voice telephone lines.

57. A customer premises equipment unit according to claim 56, further comprising:

h) AIN recovery means for recovering AIN data lost during compression of said data transmitted on at least one of said plurality of voice telephone lines.

58. A customer premises equipment unit according to claim 50, further comprising:

g) configurable call forwarding means for redirecting an inbound call received on one of said plurality of analog phone lines to an outbound call on another of said plurality of analog phone lines.

59. A customer premises equipment unit according to claim 58, further comprising:

h) secure web server means coupled to said call forwarding means for providing secure access to said call forwarding means such that said call forwarding means may be configured via the worldwide web.

60. A customer premises equipment unit according to claim 50, further comprising:

g) voicemail means for receiving voicemail on at least one of said plurality of analog phone lines; and

h) secure web server means coupled to said voicemail means for providing secure access to said voicemail means such that said voicemail means may be accessed via the worldwide web.

61. A customer premises equipment unit according to claim 50, further comprising:

g) coupling means for coupling said customer premises equipment unit to a second digital subscriber line, whereby

said at least one broadband data link adapted to be coupled to at least one personal computer can be increased in bandwidth.

62. A customer premises equipment unit for use with an enhanced digital subscriber line system which includes central office equipment which is coupled to the customer premises by a digital subscriber line, said customer premises equipment unit comprising:

a) a digital subscriber line modem adapted to be coupled to the digital subscriber line;

b) a plurality of analog phone lines adapted to be coupled to analog telephone sets;

c) at least one broadband data link adapted to be coupled to at least one personal computer;

d) multiplexer/demultiplexer means for multiplexing/de-multiplexing the plurality of analog telephone lines and the at least one broadband data link over the digital subscriber line; and

e) configurable call forwarding means for redirecting an inbound call received on one of said plurality of analog phone lines to an outbound call on another of said plurality of analog phone lines.

63. A customer premises equipment unit according to claim 62, further comprising:

f) secure web server means coupled to said call forwarding means for providing secure access to said call forwarding means such that said call forwarding means may be configured via the worldwide web.

64. A customer premises equipment unit according to claim 62, wherein:

said digital subscriber line modem is a G.lite modem.

65. A customer premises equipment unit according to claim 62, further comprising:

f) local area network coupling means for coupling said at least one broadband data link to a local area network.

66. A customer premises equipment unit according to claim 65, wherein:

said local area network coupling means includes at least one of an Ethernet port, an Ethernet hub, and a PCnet-Home port.

67. A customer premises equipment unit according to claim 62, wherein:

said multiplexer/demultiplexer means is user configurable via the at least one personal computer coupled to said at least one broadband data link.

68. A customer premises equipment unit according to claim 62, further comprising:

f) compression/decompression means for compressing/decompressing data transmitted on at least one of said plurality of voice telephone lines.

69. A customer premises equipment unit according to claim 68, further comprising:

g) AIN recovery means for recovering AIN data lost during compression of said data transmitted on said at least one of said plurality of voice telephone lines.

70. A customer premises equipment unit according to claim 62, further comprising:

f) call logging means for logging data regarding calls carried on said plurality of analog phone lines; and

g) secure web server means coupled to said call logging means for providing secure access to said data regarding calls carried on said plurality of analog phone lines.

71. A customer premises equipment unit according to claim 70, wherein:

said call logging means includes means for logging numbers dialed, logging caller ID information, logging call start time, and call end time.

72. A customer premises equipment unit according to claim 62, further comprising:

f) voicemail means for receiving voicemail on at least one of said plurality of analog phone lines; and

g) secure web server means coupled to said voicemail means for providing secure access to said voicemail means such that said voicemail means may be accessed via the worldwide web.

73. A customer premises equipment unit according to claim 62, further comprising:

f) coupling means for coupling said customer premises equipment unit to a second digital subscriber line, whereby

said at least one broadband data link adapted to be coupled to at least one personal computer can be increased in bandwidth.

74. A central office equipment unit for use with an enhanced digital subscriber line system which includes a customer premises equipment adapted to be coupled to the central office equipment unit by a digital subscriber line, said central office equipment unit comprising:

a) multiplexer/demultiplexer means for multiplexing/de-multiplexing a plurality of voice telephone lines;

b) means for coupling said central office equipment unit to the PSTN;

c) means for determining whether a call inbound from the PSTN is a fax call; and

d) means for routing fax calls to a predetermined one of said plurality of voice telephone lines.

75. A central office equipment unit according to claim 74, wherein:

said multiplexer/demultiplexer means includes means for multiplexing/de-multiplexing a plurality of voice telephone lines and at least one broadband data link over the digital subscriber line.

76. A central office equipment unit according to claim 74, wherein:

said digital subscriber line modem is a G.lite modem.

77. A central office equipment unit according to claim 74, further comprising:

e) compression/decompression means for compressing/decompressing data transmitted on at least one of said plurality of voice telephone lines.

78. A central office equipment unit according to claim 77, further comprising:

f) AIN preserving means for preserving AIN data lost during compression of said data transmitted on at least one of said plurality of voice telephone lines.

79. A central office equipment unit according to claim 74, wherein:

said multiplexer/demultiplexer means is responsive to the customer premises equipment such that the number of said plurality of voice telephones can be changed by the customer premises equipment.

80. A customer premises equipment unit for use with an enhanced digital subscriber line system which includes central office equipment which is coupled to the customer premises by a digital subscriber line, said customer premises equipment unit comprising:

a) a digital subscriber line modem adapted to be coupled to the digital subscriber line;

b) a plurality of analog phone lines adapted to be coupled to analog telephone sets;

c) at least one broadband data link adapted to be coupled to at least one personal computer;

d) multiplexer/demultiplexer means for multiplexing/de-multiplexing the plurality of analog telephone lines and the at least one broadband data link over the digital subscriber line;

e) voicemail means for receiving voicemail on at least one of said plurality of analog phone lines; and

f) secure web server means coupled to said voicemail means for providing secure access to said voicemail means such that said voicemail means may be accessed via the worldwide web.

81. A customer premises equipment unit according to claim 80, wherein:

said digital subscriber line modem is a G.lite modem.

82. A customer premises equipment unit according to claim 80, further comprising:

g) local area network coupling means for coupling said at least one broadband data link to a local area network.

83. A customer premises equipment unit according to claim 82, wherein:

said local area network coupling means includes at least one of an Ethernet port, an Ethernet hub, and a PCnet-Home port.

84. A customer premises equipment unit according to claim 80, wherein:

said multiplexer/demultiplexer means is user configurable via the at least one personal computer coupled to said at least one broadband data link.

85. A customer premises equipment unit according to claim 80, further comprising:

g) compression/decompression means for compressing/decompressing data transmitted on at least one of said plurality of voice telephone lines.

86. A customer premises equipment unit according to claim 85, further comprising:

h) AIN recovery means for recovering AIN data lost during compression of data transmitted on said at least one of said plurality of voice telephone lines.

87. A customer premises equipment unit according to claim 80, further comprising:

g) call logging means for logging data regarding calls carried on said plurality of analog phone lines; and

h) secure web server means coupled to said call logging means for providing secure access to said data regarding calls carried on said plurality of analog phone lines.

88. A customer premises equipment unit according to claim 87, wherein:

said call logging means includes means for logging numbers dialed, logging caller ID information, logging call start time, and call end time.

89. A customer premises equipment unit according to claim 80, further comprising:

g) configurable call forwarding means for redirecting an inbound call received on one of said plurality of analog phone lines to an outbound call on another of said plurality of analog phone lines.

90. A customer premises equipment unit according to claim 89, further comprising:

h) secure web server means coupled to said call forwarding means for providing secure access to said call forwarding means such that said call forwarding means may be configured via the worldwide web.

91. A customer premises equipment unit according to claim 80, further comprising:

g) coupling means for coupling said customer premises equipment unit to a second digital subscriber line, whereby

said at least one broadband data link adapted to be coupled to at least one personal computer can be increased in bandwidth.

92. A customer premises equipment unit for use with an enhanced digital subscriber line system which includes central office equipment which is coupled to the customer premises by a digital subscriber line, said customer premises equipment unit comprising:

a) a first digital subscriber line modem adapted to be coupled to the digital subscriber line;

b) a plurality of analog phone lines adapted to be coupled to analog telephone sets;

c) at least one broadband data link adapted to be coupled to at least one personal computer;

d) multiplexer/demultiplexer means for multiplexing/de-multiplexing the plurality of analog telephone lines and the at least one broadband data link over the digital subscriber line; and

e) coupling means for coupling said customer premises equipment unit to a second digital subscriber line modem adapted to be coupled to a second digital subscriber line, whereby said at least one broadband data link adapted to be coupled to at least one personal computer can be increased in bandwidth.

93. A customer premises equipment unit according to claim 92, wherein:

said digital subscriber line modem is a G.lite modem.

94. A customer premises equipment unit according to claim 92, further comprising:

f) local area network coupling means for coupling said at least one broadband data link to a local area network.

95. A customer premises equipment unit according to claim 94, wherein:

said local area network coupling means includes at least one of an Ethernet port, an Ethernet hub, and a PCnet-Home port.

96. A customer premises equipment unit according to claim 92, wherein:

said multiplexer/demultiplexer means is user configurable via the at least one personal computer coupled to said at least one broadband data link.

97. A customer premises equipment unit according to claim 92, further comprising:

f) compression/decompression means for compressing/decompressing at least one of said plurality of voice telephone lines.

98. A customer premises equipment unit according to claim 97, further comprising:

e) AIN recovery means for recovering AIN data lost during compression of said at least one of said plurality of voice telephone lines.

99. A customer premises equipment unit according to claim 92, further comprising:

f) call logging means for logging data regarding calls carried on said plurality of analog phone lines; and

g) secure web server means coupled to said call logging means for providing secure access to said data regarding calls carried on said plurality of analog phone lines.

100. A customer premises equipment unit according to claim 99, wherein:

said call logging means includes means for logging numbers dialed, logging caller ID information, logging call start time, and call end time.

101. A customer premises equipment unit according to claim 92, further comprising:

f) configurable call forwarding means for redirecting an inbound call received on one of said plurality of analog phone lines to an outbound call on another of said plurality of analog phone lines.

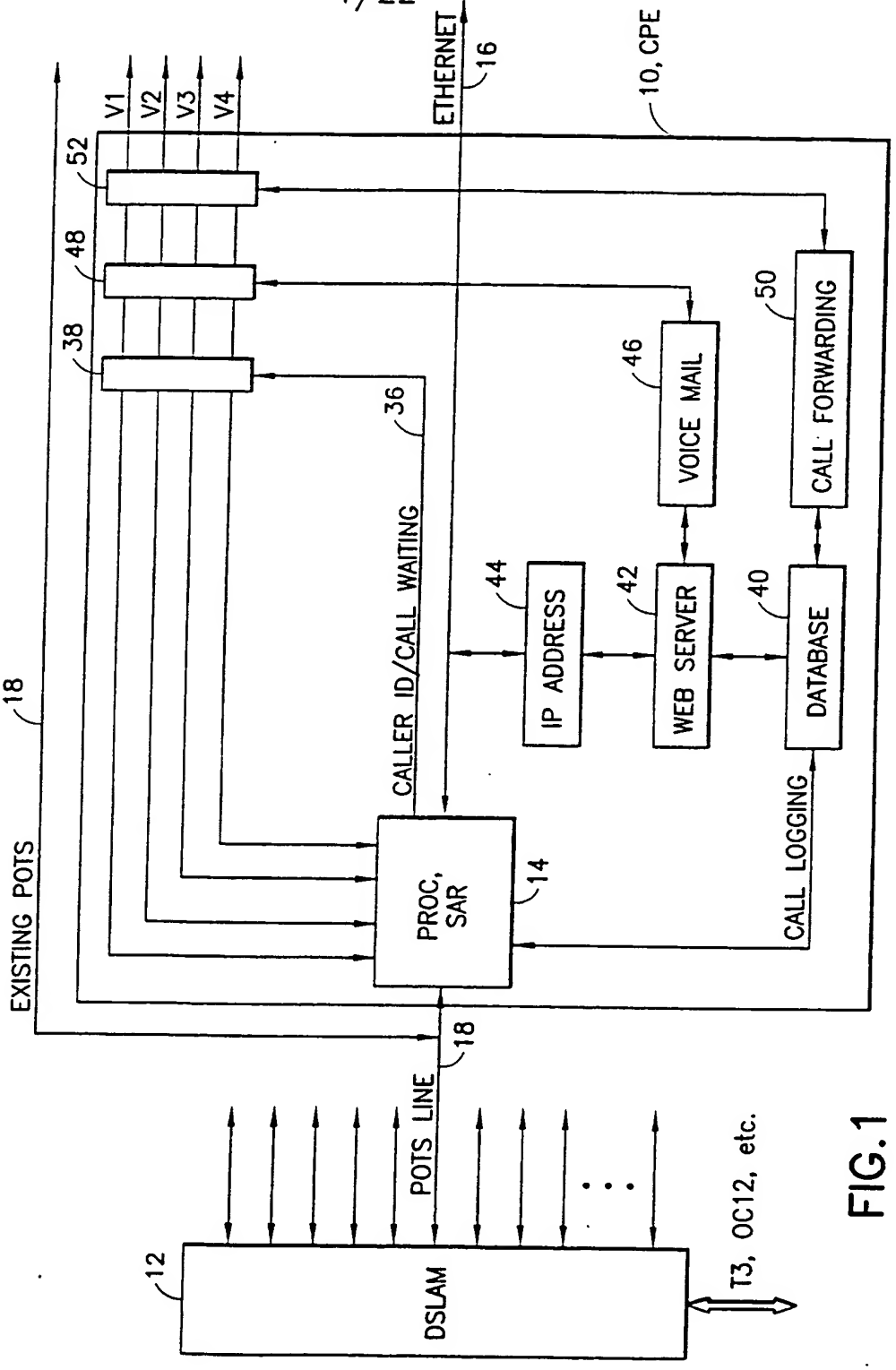
102. A customer premises equipment unit according to claim 101, further comprising:

g) secure web server means coupled to said call forwarding means for providing secure access to said call forwarding means such that said call forwarding means may be configured via the worldwide web.

103. A customer premises equipment unit according to claim 92, further comprising:

f) voicemail means for receiving voicemail on at least one of said plurality of analog phone lines; and

g) secure web server means coupled to said voicemail means for providing secure access to said voicemail means such that said voicemail means may be accessed via the worldwide web.


ETHERNET
16
10, CPE
V1
V2
V3
V4
52
48
38
36
46
VOICE MAIL
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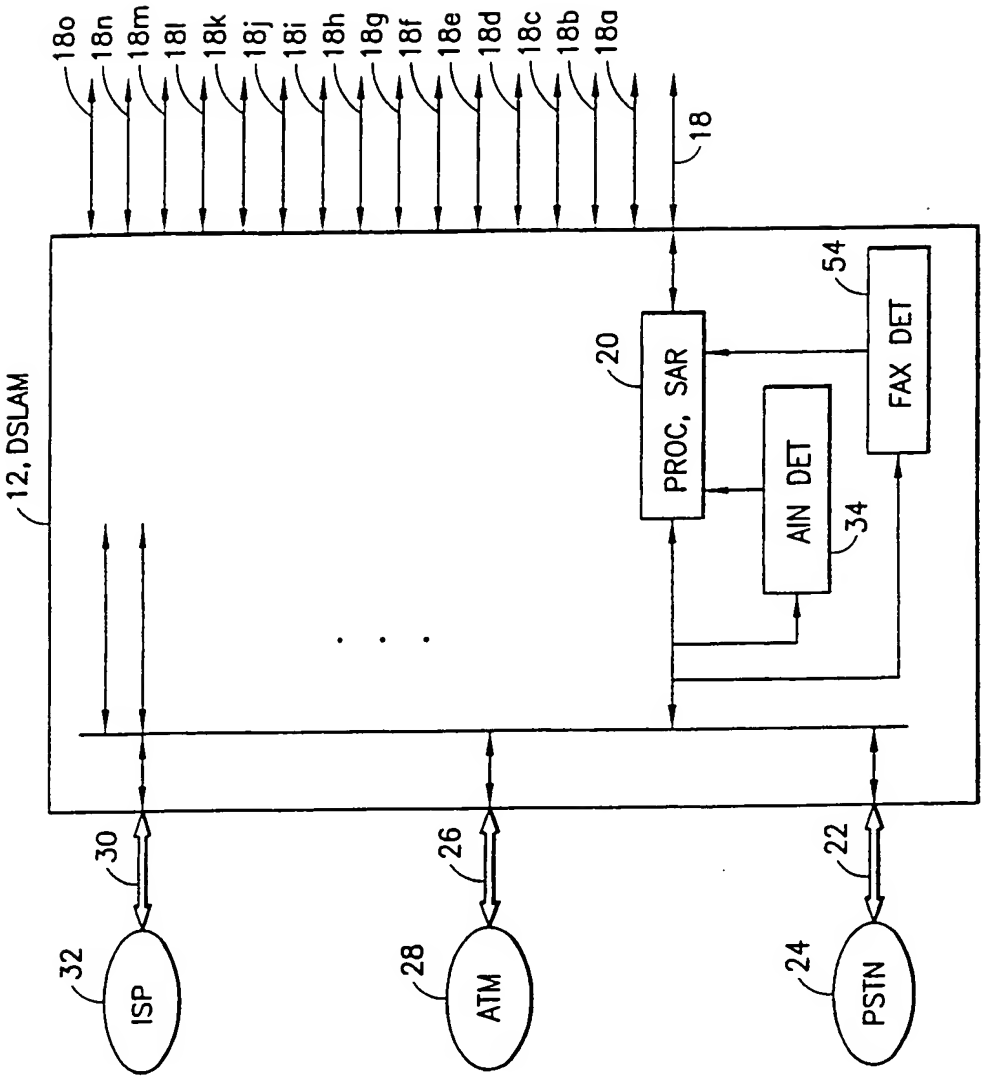
CALL FORWARDING
44
IP ADDRESS
42
WEB SERVER
40
DATABASE
CALLER ID/CALL WAITING
CALL LOGGING
18
EXISTING POTS
PROC, SAR
14
18
POTS LINE
12
DSLAM
T3, OC12, etc.

FIG. 1

FIG.2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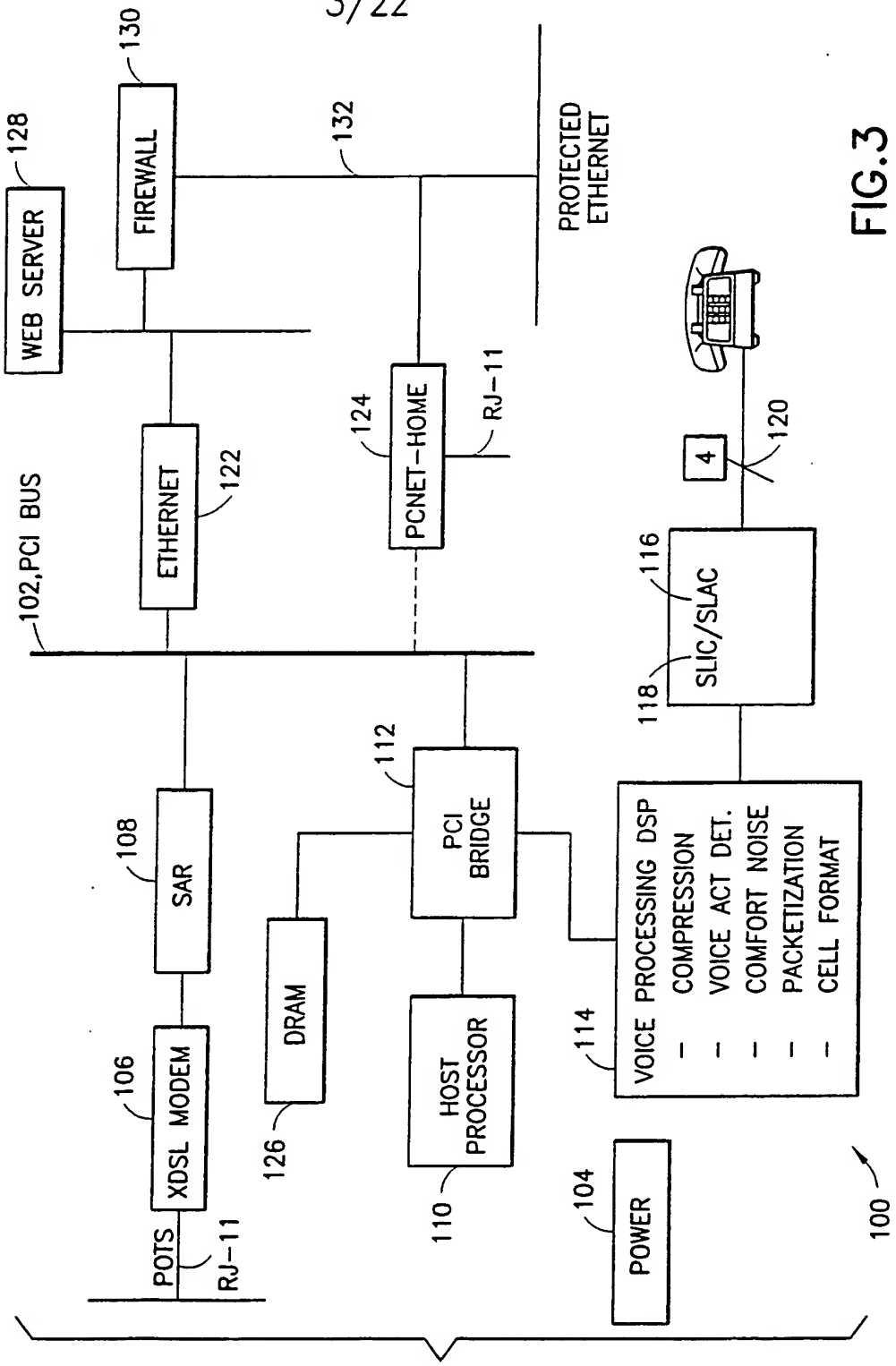
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128
FIREWALL
130
132
PROTECTED ETHERNET
102,PCI BUS
ETHERNET
122
PCNET-HOME
124
RJ-11
4
120
116
SLIC/SLAC
118
SAR
108
PCI BRIDGE
112
VOICE PROCESSING DSP
- COMPRESSION
- VOICE ACT DET.
- COMFORT NOISE
- PACKETIZATION
- CELL FORMAT
114
XDSL MODEM
106
DRAM
126
HOST PROCESSOR
110
POTS
RJ-11
POWER
104
100

FIG.3

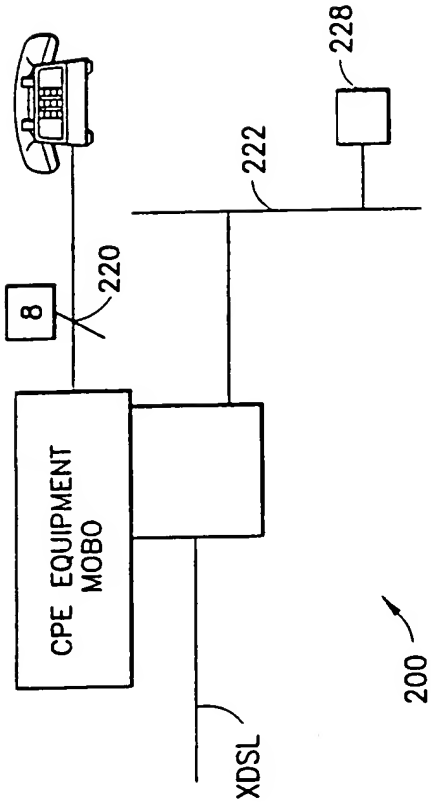
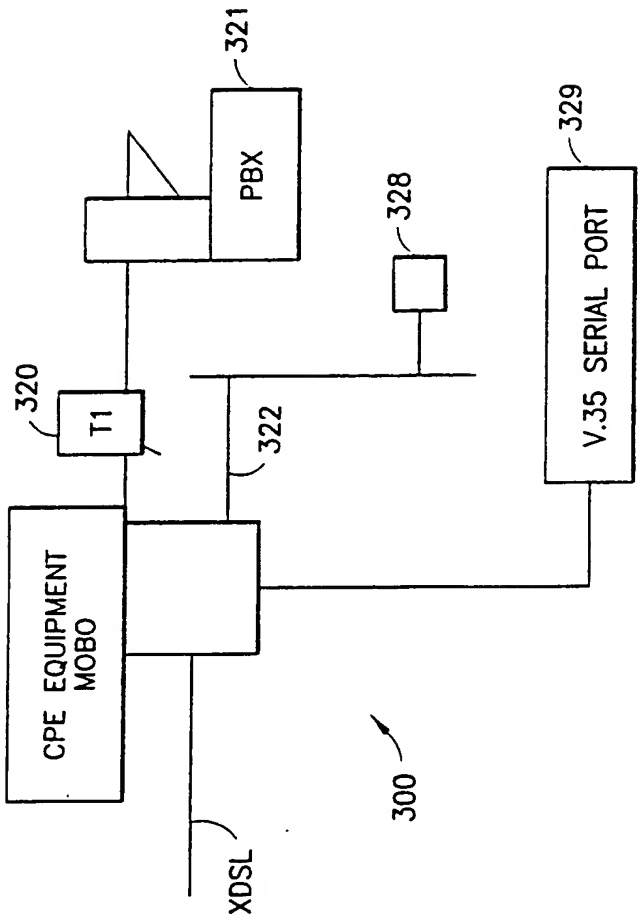


FIG.4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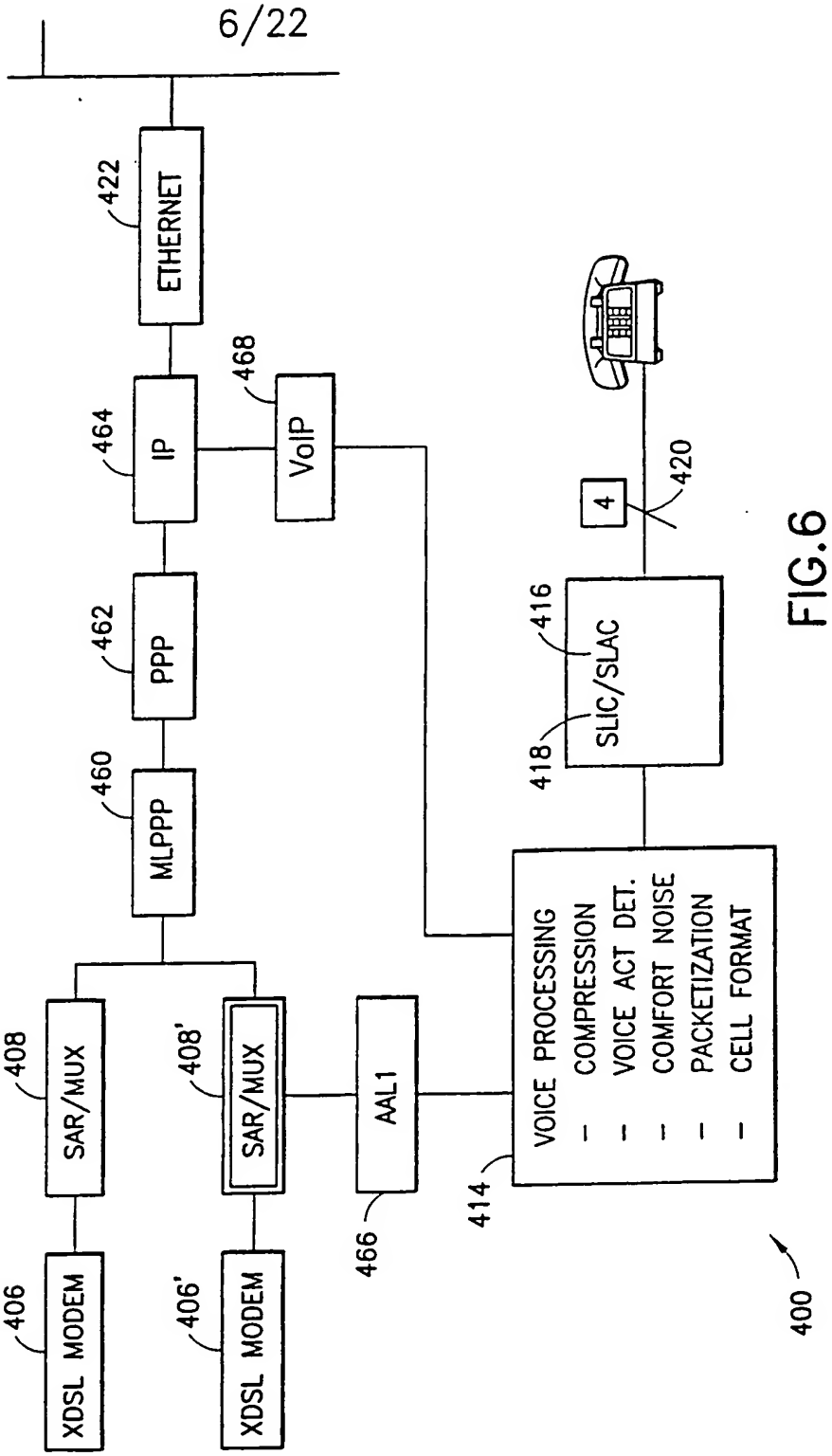
320
T1
322
CPE EQUIPMENT MOBO
300
XDSL

FIG.5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IP
464
VoIP
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PPP
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MLPPP
460
SAR/MUX
408
SAR/MUX
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AAL1
466
XDSL MODEM
406
XDSL MODEM
406'
VOICE PROCESSING
- COMPRESSION
- VOICE ACT DET.
- COMFORT NOISE
- PACKETIZATION
- CELL FORMAT
414
SLIC/SLAC
416
418
4
420
400

FIG.6

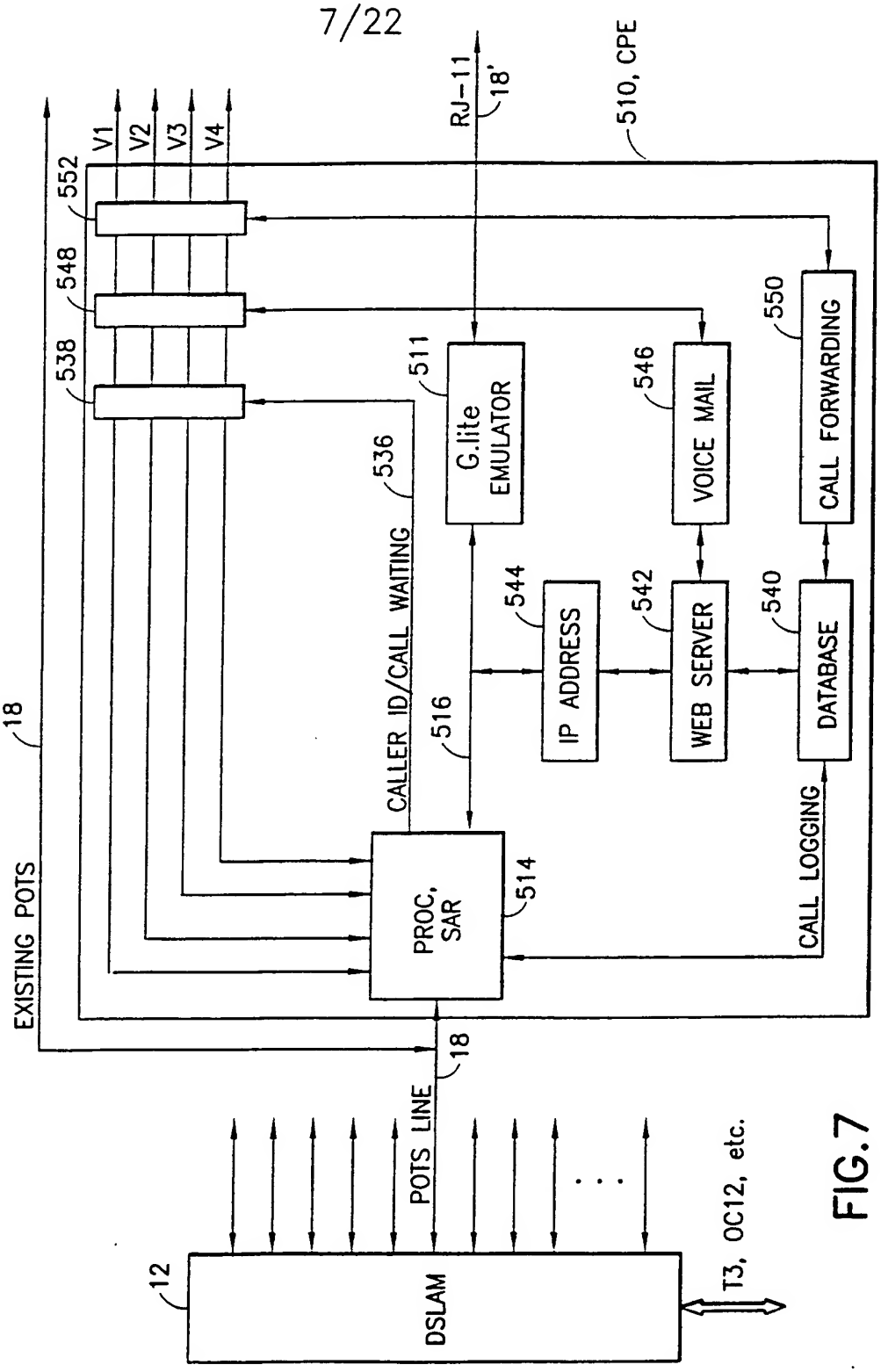
V1
V2
V3
V4
RJ-11
18'
510, CPE
552
548
538
511
G.lite EMULATOR
546
VOICE MAIL
550
CALL FORWARDING
536
CALLER ID/CALL WAITING
544
IP ADDRESS
542
WEB SERVER
540
DATABASE
516
18
EXISTING POTS
PROC, SAR
514
CALL LOGGING
18
POTS LINE
12
DSLAM
T3, OC12, etc.

FIG.7

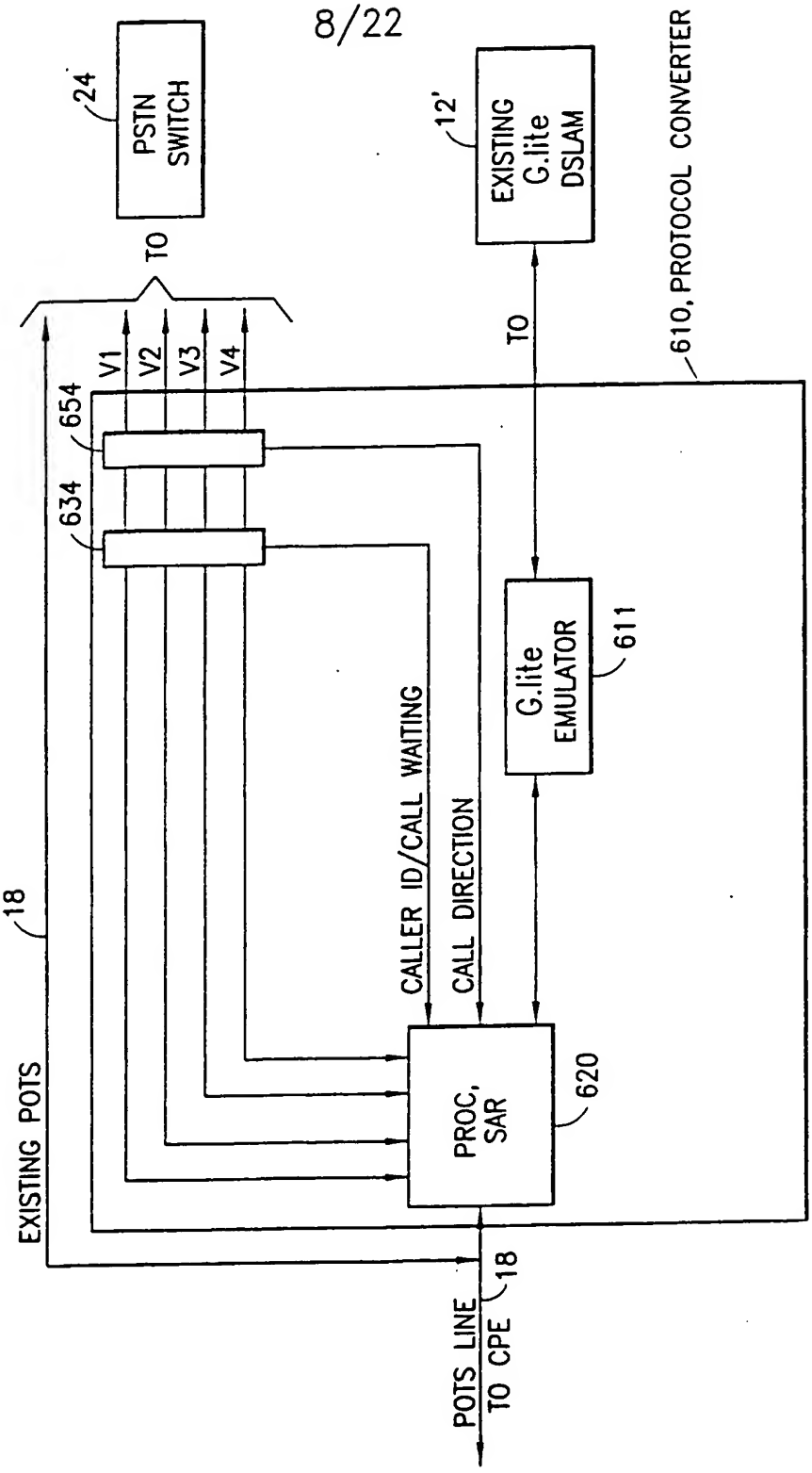
PSTN SWITCH
24
EXISTING G.lite DSLAM
12'
610, PROTOCOL CONVERTER
TO
TO
V1
V2
V3
V4
654
634
G.lite EMULATOR
611
CALLER ID/CALL WAITING
CALL DIRECTION
18
EXISTING POTS
PROC, SAR
620
POTS LINE TO CPE
18

FIG.8

```
INCOMING CALL FROM PSTM:

1       DSLAM:

2       IF SIGNALING ENABLED;
3           IF CALL SET UP
4                   SEND MANAGEMENT MESSAGE
5                   TO INDICATE CALL SET UP TO CPE;
6           IF DROP CALL
7                   SEND MANAGEMENT MESSAGE
8                   TO DROP CALL TO CPE;
9       ELSE (MUST BE CAS)
10          IF RING
11                  ENABLE CALLER ID DEMODULATOR;
12                  SEND MANAGEMENT MESSAGE FOR SET UP;
13                  LEAVE CALLER ID DEMODULATOR ON;
14          IF IDLE CODE DETECTED
15                  WAIT x SECONDS;
16                  IF TIMEOUT
17                      SEND MANAGEMENT MESSAGE
18                      TO DROP CALL

19      CPE:

20      IF CALL SET UP FROM MANAGEMENT CHANNEL
21        GET CONFIGURATION (CHANNEL _ID);
22        LOG START OF THE CALL
23        ENABLE VOICE PROCESSING
24           IF CALL FORWARDING ENABLED
25                 PROCESS OUTBOUND CALL;
26                 ENABLE VOICE PROCESSING OUTBOUND
27                 (PROVIDES CONVERSION);
28           ELSE
29                 RING PHONE
30                 ENABLE CALL PROCESSING;
31      ELSE
32        IF CALLER_ID MESSAGE
33           MODULATE CALLER ID TOWARDS SUBSCRIBER;
34      ELSE
35        IF DROP CALL FROM MANAGEMENT CHANNEL
36           LOG CALL
37           IF FORWARDING
38                DROP OUT BOUND CALL
39           DISABLE VOICE PROCESSING;
```

FIG.9

```
OUTBOUND CALL FROM CPE:
1     CPE:
2     OFF HOOK (USER PICKS UP HANDSET)
3          CALL PROCESSING
4          LOG CALL (OUTBOUND)
5          IF SIGNALING NOT ENABLED (CHANNEL_ID)
6               ENABLE VOICE PROCESSING
7          ELSE
8               IF NECESSARY DIGITS
9               SEND CALL SET UP THRU MANAGEMENT CHANNEL;
10         IF CALL ESTABLISHED
11              UPDATE CALL LOG
12    ON HOOK (USER HANGS UP)
13         TEAR DOWN CALL THRU MANAGEMENT CHANNEL
14         DISABLE VOICE PROCESSING;
15         UPDATE AND CLOSE CALL LOG;
16    FUNCTION (VOICE PROCESSING)
17         START COMPRESSION (CHANNEL_ID)
18         VOICE ACTIVITY DETECTOR
19         TONE DETECTOR
20         ECHO CANCELLER
21         FORMAT PACKETS TO CHANNEL CONFIG;
22    FUNCTION (CALL PROCESSING)
23         PROVIDE DIAL TONE;
24         COLLECT AND PASS DIGITS TO HOST PROCESSOR;
25    DSLAM:
26    IF SIGNALING ENABLED;
27         IF CALL SET UP FROM MANAGEMENT CHANNEL
28              SEND CALL SET UP TR303
29         IF DROP CALL FROM MANAGEMENT CHANNEL
30              DROP CALL USING TR303;
31         IF CALL PROCEEDING FROM PSTN;
32              INDICATE CALL PROCEEDING USING MANAGEMENT CHANNEL;
33         IF CALL ESTABLISHED
34              INDICATE THRU MANAGEMENT CHANNEL TO CPE;
35    ELSE (MUST BE CAS)
36         IF IDLE CODE DETECTED AND CHANNEL IS ON
37              WAIT x SECONDS;
38              IF TIMEOUT
39                 SEND MANAGEMENT MESSAGE
40                 TO DROP CALL
```

FIG.10

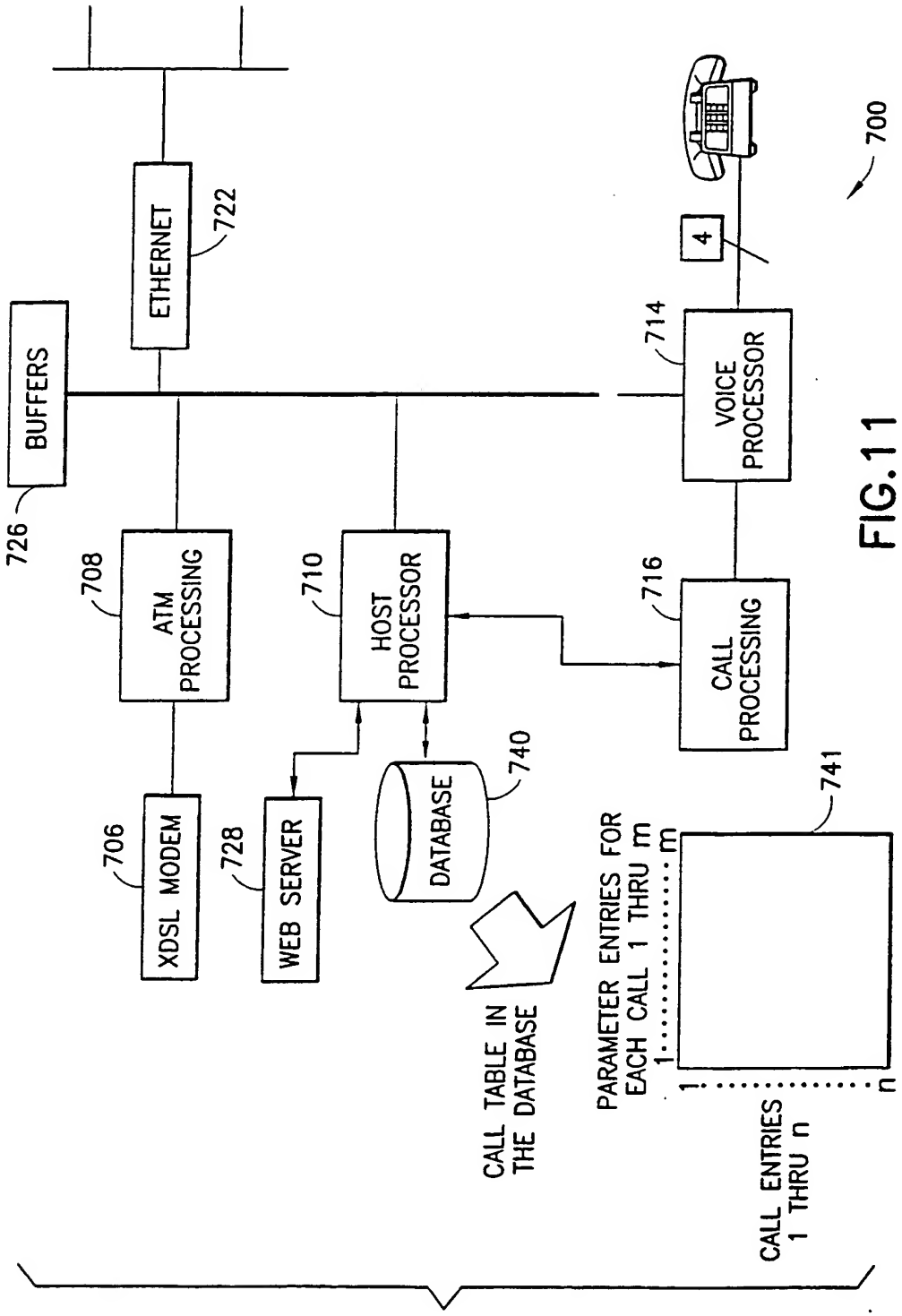
700
ETHERNET
722
BUFFERS
726
4
VOICE PROCESSOR
714
ATM PROCESSING
708
HOST PROCESSOR
710
CALL PROCESSING
716
XDSL MODEM
706
WEB SERVER
728
DATABASE
740
741
PARAMETER ENTRIES FOR EACH CALL 1 THRU m
1 ..... m
1 ..... n
CALL ENTRIES 1 THRU n
CALL TABLE IN THE DATABASE

FIG.11

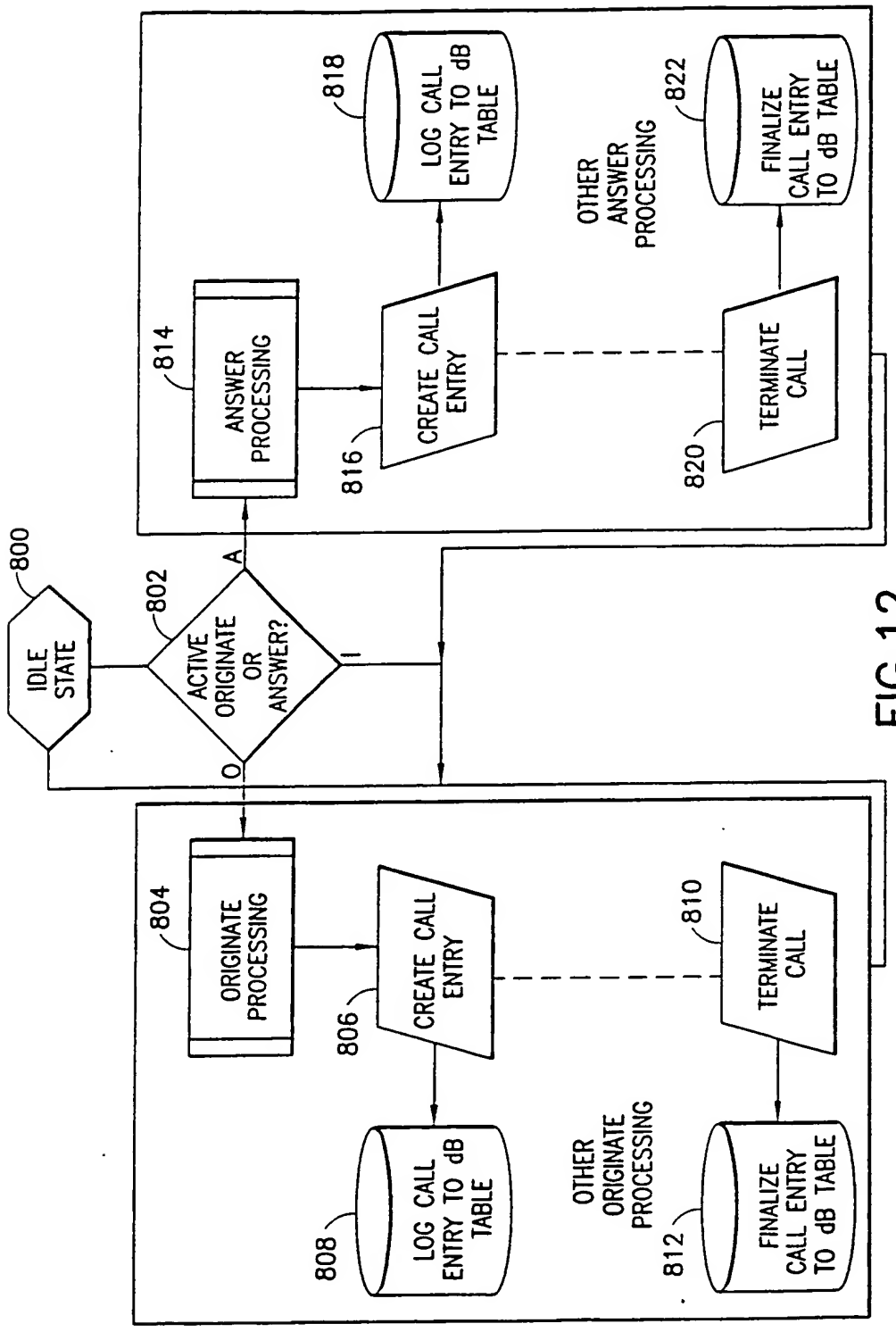
800
IDLE STATE
802
ACTIVE ORIGINATE OR ANSWER?
A
O
I
804
ORIGINATE PROCESSING
806
CREATE CALL ENTRY
808
LOG CALL ENTRY TO dB TABLE
810
TERMINATE CALL
812
FINALIZE CALL ENTRY TO dB TABLE
OTHER ORIGINATE PROCESSING
814
ANSWER PROCESSING
816
CREATE CALL ENTRY
818
LOG CALL ENTRY TO dB TABLE
820
TERMINATE CALL
822
FINALIZE CALL ENTRY TO dB TABLE
OTHER ANSWER PROCESSING

FIG.12

13/22

```
1   ORIGINATE PROCESSING:

2   CREATE CALL ENTRY;
3       GET NEXT ENTRY POINTER
4           INSERT CALLER NUMBER
5           INSERT CALLED NAME (IF AVAILABLE)
6           INSERT TYPE-ORIGINATE
7           INSERT CHANNEL ID (PHONE ON SOHO)
8           INSERT START TIME
9       PASS ENTRY POINTER TO ORIGINATE CALL PROCESSING

10  TERMINATE CALL
11      GET ENTRY POINTER
12          INSERT END TIME
13          UPDATE TYPE-ORIGINATE
14                  (COMPLETED/UNCOMPLETED)

15  ANSWER PROCESSING:

16  CREATE CALL ENTRY;
17      GET NEXT ENTRY POINTER
18          INSERT CALLER ID NUMBER
19          INSERT CALLER ID NAME (IF AVAILABLE)
20          INSERT TYPE-ANSWER
21          INSERT CHANNEL ID (PHONE ON SOHO)
22          INSERT START TIME
23      PASS ENTRY POINTER TO ANSWER CALL PROCESSING

24  TERMINATE CALL
25      GET ENTRY POINTER
26          INSERT END TIME
27          UPDATE TYPE-ANSWER
28                  (ANSWERED/TO VOICEMAIL/FORWARDED)
```

FIG.13

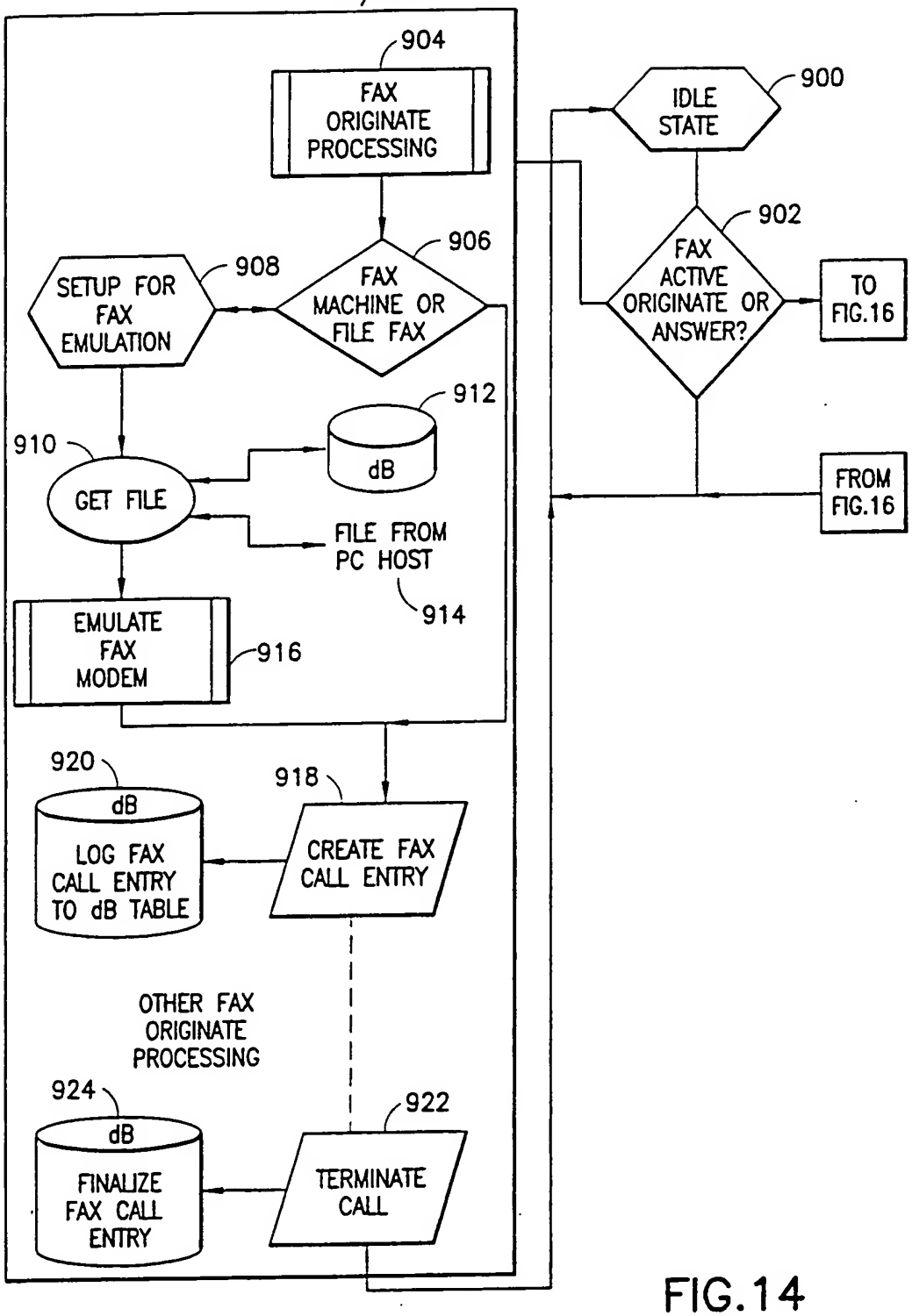
904
FAX ORIGINATE PROCESSING
900
IDLE STATE
902
FAX ACTIVE ORIGINATE OR ANSWER?
TO FIG.16
FROM FIG.16
906
FAX MACHINE OR FILE FAX
908
SETUP FOR FAX EMULATION
912
dB
910
GET FILE
FILE FROM PC HOST
914
EMULATE FAX MODEM
916
920
dB
LOG FAX CALL ENTRY TO dB TABLE
918
CREATE FAX CALL ENTRY
OTHER FAX ORIGINATE PROCESSING
924
dB
FINALIZE FAX CALL ENTRY
922
TERMINATE CALL

FIG.14

```
1    FAX ORIGINATE PROCESSING:

2    IF FAX MACHINE
3        GO TO NORMAL FAX CALL PROCESS
4    ELSE FILE FAX
5    GO TO FAX EMULATION PROCESS;
6    SET UP FAX EMULATION
7    GET FILE
8                LOCAL STORAGE
9                OR
10               LAN CONNECTED HOST
11       EMULATE FAX MODEM;
12   NORMAL FAX CALL PROCESS
13   CREATE CALL ENTRY;
14           GET NEXT ENTRY POINTER
15                   INSERT FAX CALLED NUMBER
16                   INSERT FAX CALLED NAME (IF AVAILABLE)
17                   INSERT TYPE-ORIGINATE
18                   INSERT CHANNEL ID (PHONE ON SOHO)
19                   INSERT START TIME
20           PASS ENTRY POINTER TO ORIGINATE CALL PROCESSING

21   TERMINATE CALL
22   GET ENTRY POINTER
23                   INSERT END TIME
24                   UPDATE TYPE-ORGINATE
25                           (COMPLETED/UNCOMPLETED)
```

FIG.15

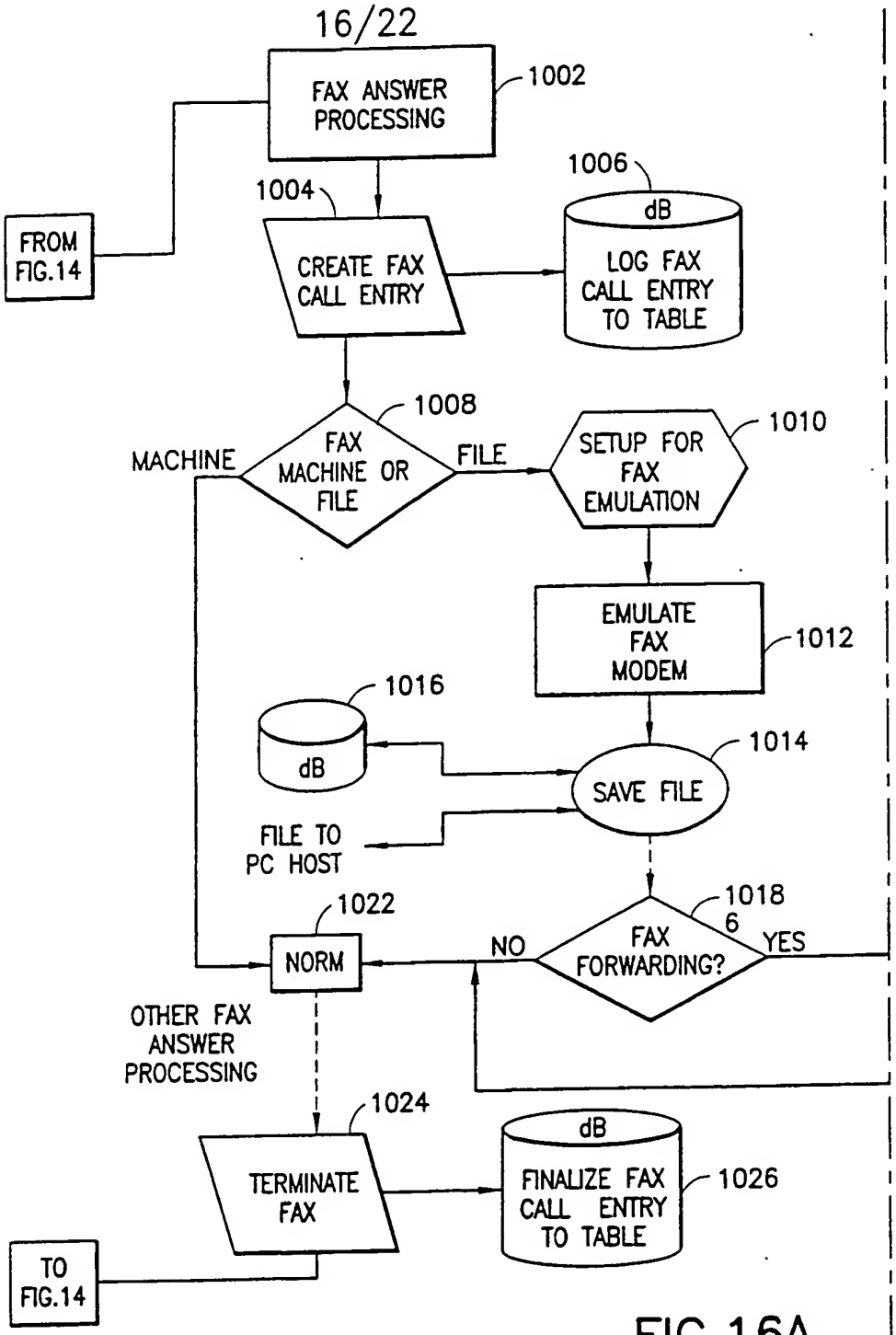

FIG.16A

FIG.16A | FIG.16B FIG.16

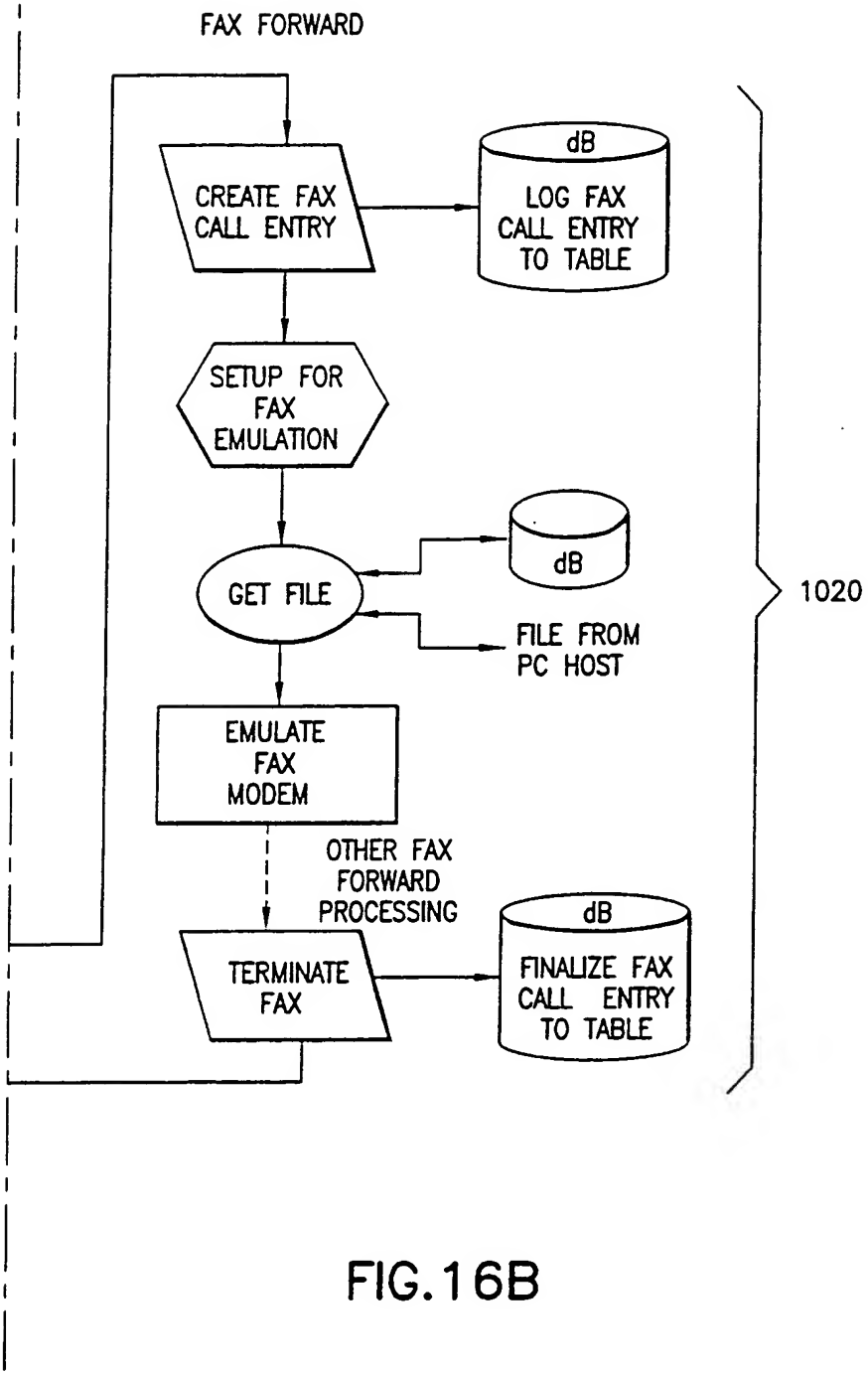
FAX FORWARD
CREATE FAX CALL ENTRY
dB
LOG FAX CALL ENTRY TO TABLE
SETUP FOR FAX EMULATION
GET FILE
dB
FILE FROM PC HOST
EMULATE FAX MODEM
OTHER FAX FORWARD PROCESSING
TERMINATE FAX
dB
FINALIZE FAX CALL ENTRY TO TABLE
1020

FIG.16B

```
1   FAX ANSWER PROCESSING:

2   CREATE CALL ENTRY;
3         GET NEXT ENTRY POINTER
4               INSERT FAX NUMBER
5               INSERT FAX CALLER ID # (IF AVAILABLE)
6               INSERT FAX CALLER NAME (IF AVAILABLE)
7               INSERT TYPE-ANSWER
8               INSERT CHANNEL ID (PHONE ON SOHO)
9               INSERT START TIME
10        PASS ENTRY POINTER TO FAX ANSWER CALL PROCESSING
11  IF FAX MACHINE
12     GO TO NORMAL FAX ANSWER CALL PROCESS
13  SETUP FAX EMULATION
14     EMULATE FAX MODEM;
15     RECEIVE FAX FILE
16        SET FOR SAVE TO LOCAL STORAGE
17              SAVE RECEIVED FAX FILE;
18        ELSE SET FOR SAVE TO LAN CONNECTED HOST
19              SAVE RECEIVED FAX FILE;
20  IF FAX FORWARDING NOT ENABLED;
21     GO TO NORMAL FAX CALL PROCESS;
22  CREATE CALL ENTRY;
23        GET NEXT ENTRY POINTER
24              INSERT FAX CALLED NUMBER
25              INSERT FAX CALLED NAME (IF AVAILABLE)
26              INSERT TYPE-FAX ORIGINATE FORWARD
27              INSERT CHANNEL ID (PHONE ON SOHO)
28              INSERT START TIME
29        PASS ENTRY POINTER TO FAX FORWARD ORIGINATE CALL PROCESSING
```

FIG.17A

FIG.17A

FIG.17B

FIG.17

```
30      FAX FORWARD CALL
31          SETUP FAX EMULATION
32              GET FILE
33                      LOCAL STORAGE OR LAN CONNECTED STORAGE
34          EMULATE FAX MODEM;
35      NORMAL FAX FORWARD CALL PROCESS
36          PASS ENTRY POINTER;
37      GET ENTRY POINTER
38              INSERT END TIME
39              UPDATE TYPE-FAX FORWARD ORIGINATE
40                      (COMPLETED/UNCOMPLETED)
41      NORMAL FAX ANSWER PROCESSING
42          PASS ENTRY POINTER;
43      GET ENTRY POINTER
44                  INSERT END TIME
45                  UPDATE TYPE-FAX ANSWER
46                      (FORWARDED)
47                      (COMLETED/UNCOMPLETED)
```

FIG.17B

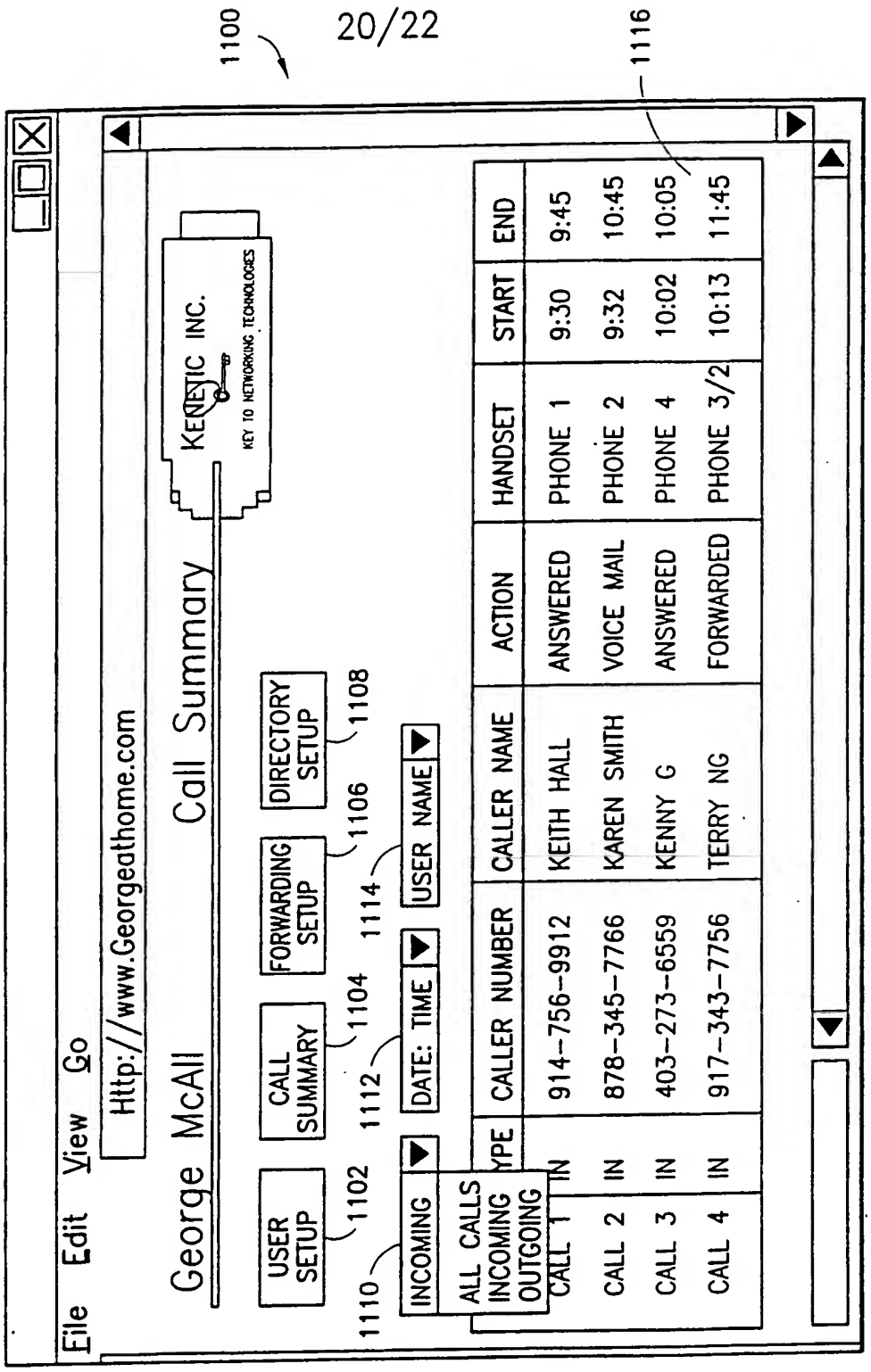
1100
1116
File Edit View Go
Http://www.Georgeathome.com
George McAll
Call Summary
KENETIC INC.
KEY TO NETWORKING TECHNOLOGIES
USER SETUP
CALL SUMMARY
FORWARDING SETUP
DIRECTORY SETUP
1102
1104
1106
1108
1110
1112
1114
INCOMING
DATE: TIME
USER NAME
ALL CALLS
INCOMING
OUTGOING
TYPE
CALLER NUMBER
CALLER NAME
ACTION
HANDSET
START
END
CALL 1 IN 914-756-9912 KEITH HALL ANSWERED PHONE 1 9:30 9:45
CALL 2 IN 878-345-7766 KAREN SMITH VOICE MAIL PHONE 2 9:32 10:45
CALL 3 IN 403-273-6559 KENNY G ANSWERED PHONE 4 10:02 10:05
CALL 4 IN 917-343-7756 TERRY NG FORWARDED PHONE 3/2 10:13 11:45

FIG.18

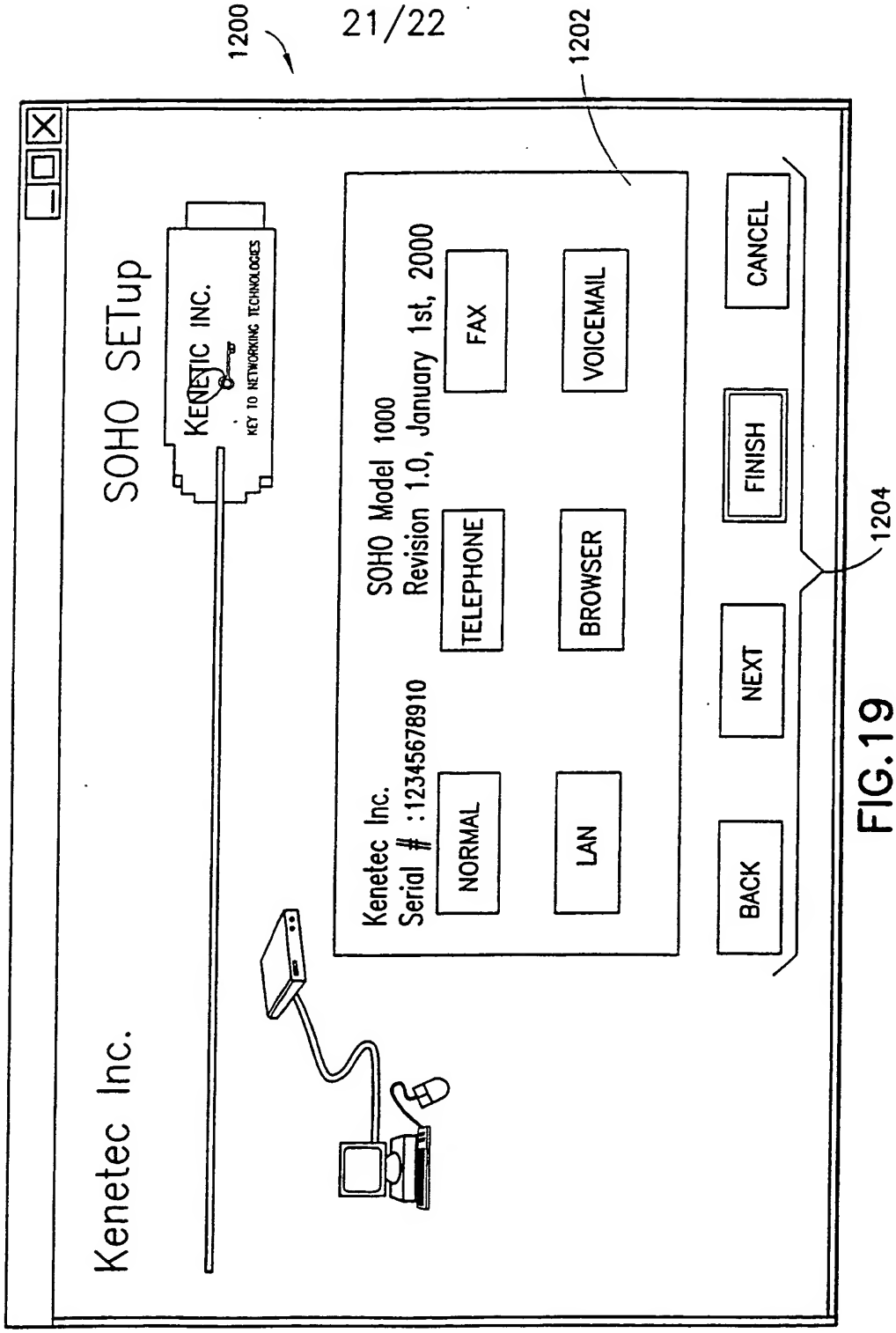
1200
1202
1204
SOHO SETup
KENETIC INC.
KEY TO NETWORKING TECHNOLOGIES
Kenetec Inc.
Kenetec Inc.
Serial # :12345678910
SOHO Model 1000
Revision 1.0, January 1st, 2000
NORMAL
TELEPHONE
FAX
VOICEMAIL
LAN
BROWSER
BACK
NEXT
FINISH
CANCEL

FIG.19

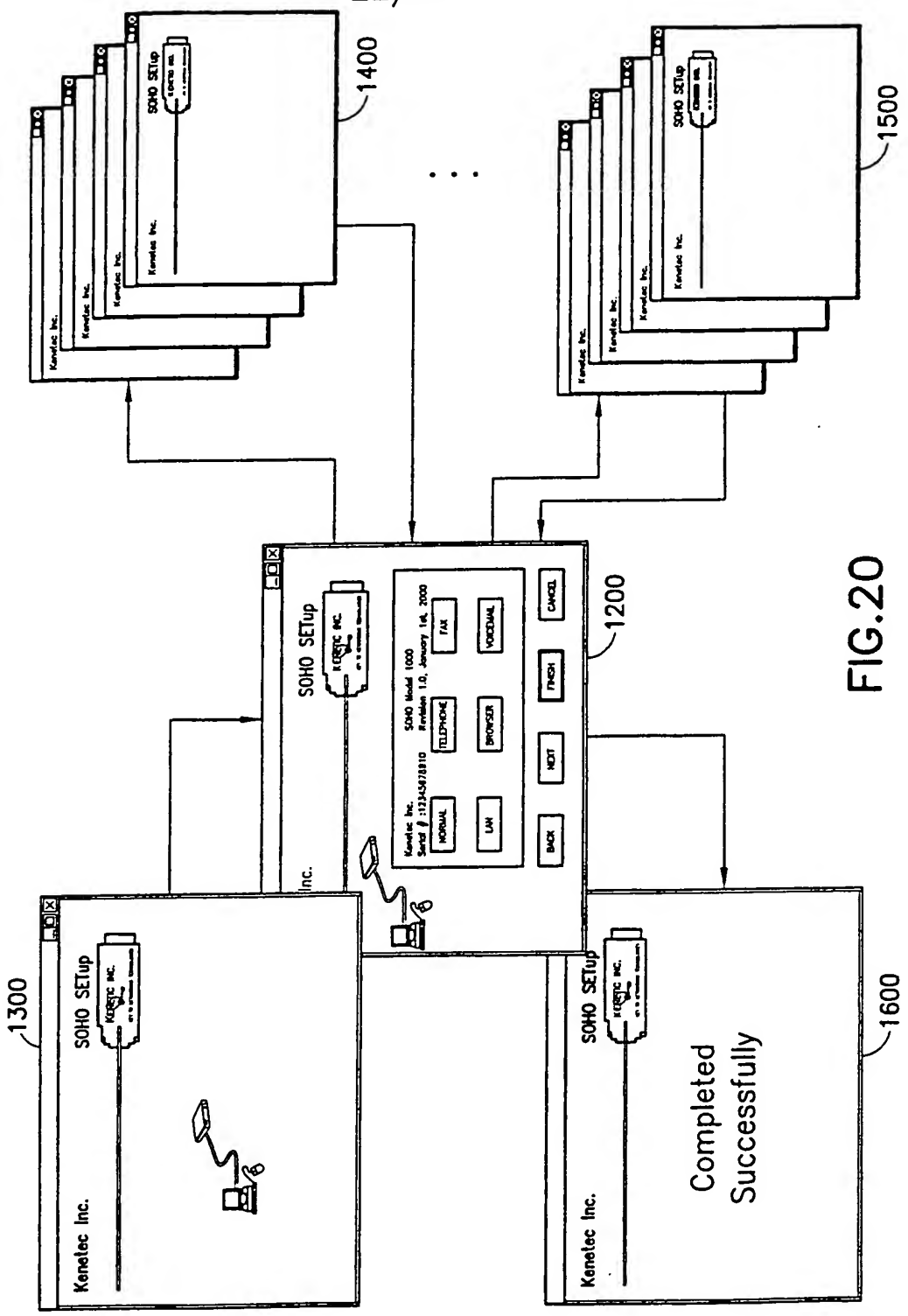
1400
1500
1200
1300
1600
SOHO SETup
Kenetec Inc.
Completed
Successfully

FIG.20

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/22111

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) :H04N 1/00
US CL :358/407; 370/351; 379/93.05
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 358/1.15, 407, 425, 442, 443, 468; 370/351-356, 359, 401, 463; 379/93.01, 93.05-93.09, 93.14, 399

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST
search terms: DSL, CPE, AIN, g.lite, multiplexer, modem, voice

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4,740,963 A (ECKLEY) 26 APRIL 1988, see entire document.	1, 2, 7, 8, 11, 15, 16, 22, 23, 36-39
Y		3-6, 9, 10, 12-14, 34, 40-49

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search
02 OCTOBER 2000

Date of mailing of the international search report
22 NOV 2000

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703) 305-3230

Authorized officer
JOSEPH R. POKRZYWA
Telephone No. (703) 305-3800/4700

Form PCT/ISA/210 (second sheet) (July 1998) *

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/22111

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ------- Y	US 5,610,910 A (FOCSANEANU et al) 11 MARCH 1997, see entire document.	16, 17, 19, 21-24, 26-29, 50, 53, 55-63, 65, 67-70, 72, 73, 80, 82, 84-87, 89-92, 94, 96-99, 101-103 ---------- 1-15, 18, 20, 25, 33-35, 40-49, 51, 52, 54, 64, 66, 71, 74-79, 81, 83, 88, 93, 95, 100
X ------- Y	US 5,898,761 A (MCHALE et al) 27 APRIL 1999, see entire document.	30, 31 ---------- 1-15, 20, 25, 32-35, 43, 45, 51, 54, 66, 71, 74-79, 83, 88, 95, 100
Y, P	US 6,052,411 A (MUELLER et al) 18 APRIL 2000, col. 8, lines 1-2.	3, 18, 32, 41, 52, 64, 76, 81, 93
A	US 5,577,115 A (DEUTSCH et al) 19 NOVEMBER 1996, see entire document.	1-35, 39-43, 50-103
A	US 5,790,173 A (STRAUSS et al) 04 AUGUST 1998, see entire document.	36-38
A	US 5,889,856 A (OTOOLE et al) 30 MARCH 1999, see entire document.	1-35, 39-43, 50-103
A	US 5,923 ·,659 A (CURRY et al) 13 JULY 1999, see entire document.	36-49

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/22111

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/22111

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I, claim(s) 1-15, drawn to an enhanced DSL system which includes customer premises equipment and central office equipment.
Group II, claim(s) 16-29, 39-43, 50-73, and 80-103, drawn to a customer premises equipment unit for use with an enhanced DSL system.
Group III, claim(s) 30-35, and 74-79, drawn to a central office equipment unit for use with an enhanced DSL system.
Group IV, claim(s) 36-38, and 44-49, drawn to an apparatus for recovering AIN data in a compressed voice telephone link.

The inventions listed as Groups I through IV do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Regarding ***claims 1-15 of Group I***, the special technical features include customer premises equipment having a first means for multiplexing/de-multiplexing a plurality of voice telephone lines over a single DSL line, being user configurable, whereby a user can select the number of the plurality of voice lines, and central office equipment including a second multiplexing/de-multiplexing means.

Regarding ***claims 16-29, 39-43, 50-73, and 80-103 of Group II***, the special technical features include customer premises equipment comprising a DSL modem adapted to be coupled to the DSL, a plurality of analog phone lines, and multiplexer/de-multiplexer means.

Regarding ***claims 30-35, and 74-79 of Group III***, the special technical features include central office equipment comprising multiplexer/de-multiplexer means, means for coupling the central office equipment unit to the PSTN, wherein the multiplexer/de-multiplexer means is responsive to customer premises equipment such that the number of the plurality of voice telephone lines can be changed by the customer premises equipment.

Regarding ***claims 36-38, and 44-49 of Group IV***, the special technical features include apparatus for recovering AIN data comprising AIN data detection means, AIN data encoding means, digital data transmission means, digital data detection means, and AIN data remodulation means.